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MAGNIFYING POWERS MOST USEFUL IN OBSERVING WITH LARGE TELESCOPES.

By Prof. E. E. Barnard, of the Lick Observatory.

Mr. Ranyard is quite right about the superiority of small powers for planetary work with a large telescope. I have always used the full aperture of the thirty-six-inch in my work. It is possible, however, that planetary detail might be somewhat improved with a slight reduction of aperture.

My experience with the higher powers has been principally in the measurement of a list of close and difficult double stars which I am observing at the request of Mr. Burnham. What experience I have had with the thirty-six-inch has been very varied. It has consisted in the observation of the double stars referred to, the measurement of the positions of very faint and distant comets, observations of nebulæ, of planetary details, and the positions of satellites.

On double stars I have found it always satisfactory to use one thousand diameters if the night will stand it, because of the greater scale and ease of measurement. I have used two thousand six hundred with perfect satisfaction, but this requires a perfect night and is only useful where the stars are bright and not too unequal. With very close stars I should always prefer this power when the night will permit its use.

Mr. Burnham's great experience in this line would, however, make him far more competent to speak of the powers useful for this class of work with the great telescope than I am.

In reference to the planets, I can never get any satisfaction from the surface markings of Jupiter with as high a power as one thousand, not even on the best nights. Only the coarser details can then be made out. I find it seldom satisfactory to use even five hundred and twenty. The lower power of three hundred and fifty is always preferable on this planet, and a similar remark also applies to Mars. Five hundred and twenty gives a fine image of Saturn, and sometimes one thousand diameters is useful, though the lower power is to be preferred. This singular peculiarity has always been apparent to me with all telescopes in observing Jupiter and Saturn. Saturn will stand a much higher power than Jupiter, the latter becoming vague and vapory with high powers. The moons of Jupiter, however, readily stand one thousand, giving clearly-defined discs with more or less stray light. The newly-discovered fifth satellite does not stand magnifying well and is lost with the higher powers.

I have lately been measuring the dimensions of the asteroids Ceres, Pallas, and Vesta. They present well-defined measurable discs and are very satisfactorily observed with one thousand diameters, and on a good night I would much prefer this power.

I think Mr. Ranyard's estimate of the powers that can be used on the planets with the thirty-six-inch—forty or fifty diameters to the inch—is, if anything, too high, twenty or thirty would more nearly represent the values, and for Jupiter ten to fifteen, in my opinion, would be nearer the mark.

In comet observations much will depend on the comet. A small comet, with a definite condensation, is best seen with powers of two hundred and sixty or three hundred and fifty, and sometimes with five hundred and twenty and seven hundred. It is surprising how some comets will stand magnifying. If the comet is large and diffused it had best not be observed with the thirty-six-inch at all, as the great separating power of that instrument would diffuse it into nothing. I remember one night Mr. Burnham and I tried to observe a nebula which was quite noticeable in the finder, and we finally gave it up in despair without having seen the slightest trace of it in the thirty-six-inch with any power. But for the planetary and small indefinite nebulæ the great telescope is pre-eminent.

There is a very large eye-piece belonging to this instrument that is very seldom used. The field lens is six inches in diameter, and it will take in the entire moon. Where one would expect this to be specially useful—for faint objects—it is very disappointing. The sky becomes whitish and milky in it, and one thus loses a delicate faint object for want of blackness of field. I tried comets 1889 I. and 1889 V., when very distant from us, with this eye-piece, but could not see a trace of them on account of the brightness of the field; but with powers of three hundred and fifty and five hundred and twenty I followed the first of these objects over one hundred million miles beyond the orbit of Jupiter, and the other I observed nearly a year after it was lost to all other telescopes. A view of the Orion nebula through this large eye-piece is, however, very fine.

In reply to Mr. C. Robinson's letter published in Knowledge for March, p. 64, I would remark that the blue colour about Jupiter or a bright star in the thirty-six-inch is much greater than in a good six-inch telescope. The secondary spectrum is much more pronounced in the thirty-six-inch than in the twelve-inch.

In speaking of the Orion nebula, there is a feature in connection with some of its details that I have never seen

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mentioned, and which, though I first saw it with the large eye-piece referred to, is well seen in the twelve-inch. The southern sharply defined edge of the great bright area in which is located the trapezium is distinctly bordered by a dull red. There are other parts about it also that show this colour. It is best seen in strong moonlight. The three hundred and fifty eye-piece shows it also distinctly. I am not prepared to say just what this phenomenon is. I hardly think it is a telescopic effect, because I have never seen it connected with any other of the nebulæ. I first saw it some three or four years ago.

Mount Hamilton, California,
April 6th, 1894.

Remarks by Mr. S. W. Burnham *on the same subject.*

Referring to the note on the powers that can be usefully used on large telescopes, which appears in the March number of Knowledge, in which reference is made to me and to my friend Mr. Barnard, I would say that the highest power used by us on the thirty-six-inch refractor at Mount Hamilton was two thousand six hundred. The focal length of this eye-piece was given as one-fifth of an inch, and its power was therefore originally called three thousand three hundred, but a subsequent careful measurement reduced this to two thousand six hundred. The other powers in general use on the micrometer were one thousand nine hundred, one thousand five hundred, one thousand seven hundred, five hundred and twenty, and three hundred and sixty. The lowest power was very rarely used by me and, aside from the measurements of nebulæ, probably not half a dozen times a year. The eye-piece next to that was used in the measures of very wide couples, where a large field was necessary, and occasionally for extremely faint companions to bright stars, where the distance was several seconds. Most of my measures were made with powers of seven hundred, one thousand, and one thousand five hundred. My practice has always been, in measuring close pairs, to use the lowest power which will give the separation necessary for good measures. The nights are not frequent, even at Mount Hamilton, when the highest power can be used to advantage; but there are many very close double stars which cannot be measured with anything else, and one must wait for a favourable opportunity for such work. I kept on my working list most of the very close pairs known to be in rapid motion, and those which for a long time had been regarded as single. Where the distances were 0·15″ or less, the measures were made with the two highest powers, and the closest of these were always measured with two thousand six hundred. Occasionally I have examined a doubtful object, under exceptionally favourable conditions, with one lens of the highest eye-piece removed. This, of course, gave a higher power—I do not know what it would be—but the use of a single lens was only an experiment, as the micrometer could not be used in that way.

So far as my experience goes, these very high powers are useless for anything but extremely close double stars. I have looked at Saturn, Jupiter, and other planets many times with high powers, and under no circumstances could as much be seen in the way of surface details as with moderate powers. For all ordinary purposes, I should say the range of useful eye-pieces would be within the limit suggested—viz., about fifty to the inch of aperture.

Of course, I always used the full aperture of the thirty-six-inch refractor in all my double star work. After using a large instrument, one does not voluntarily take a smaller one, nor reduce the aperture for any visual purpose. Nothing is gained with any condition of the air by cutting down the objective; but there are some nights so poor—and I have never seen worse ones than we had at Mount Hamilton at times—when a small instrument is as good as a large one, but these are occasions when no one would think of attempting to make any measures.

Chicago.

ON THE MOUNTING OF LARGE REFLECTING TELESCOPES.

By Sir Howard Grubb, F.R.S., &c., &c.

WHATEVER may be said as to the relative merits and demerits of reflectors and refractors, there can be very little doubt that, for the present, we must look to reflectors as offering the most likely form by which to increase, to any very large extent, the light-grasping power of our telescopes. The difficulties in obtaining optical glass have of late years been considerably reduced, and at the present time discs of thirty inches diameter are not much more difficult to obtain than discs of half that diameter were twenty years ago. There does not, however (in spite of recent advances), seem to be much chance of obtaining discs of optical glass which will enable us to construct an objective which would equal in light-grasping power such an instrument as Lord Rosse's six-foot reflector, which has been in existence for half a century.

It seems strange that fifty years have been allowed to elapse without any attempt being made to develop the power of the reflector. This is not due to any optical imperfections, or any great difficulty in making the optical parts perfect, as is clearly proved by the splendid work accomplished with reflectors by Draper, De la Rue, Common, Roberts and others. Modern astronomical research, however, requires that all instruments should be mounted with an accuracy and delicacy which it was scarcely possible to obtain, even if it had appeared necessary, at the time when Lord Rosse's six-foot mirror was mounted. Whenever the reflecting telescope has been mounted with the rigidity and stability required for stellar photographic work, when the clock-driving has been sufficiently accurate, and when the correcting slow motions have been sufficiently delicate, the mirror has held its own against the object-glass; and, at the present day, if the six-foot mirrors of the late Lord Rosse were properly mounted on equatorials which would carry them with the accuracy required for modern work, it cannot be doubted that they would do magnificent work in the hands of present-day astronomers.

There appears to be some probability that an attempt will be made by our neighbours on the other side of the English Channel to make a distinct advance in this direction. In view of the rumours of a ten-foot reflector to be constructed and mounted for the great exhibition in Paris in 1900, it may be interesting to consider some of the difficulties that will probably arise in the construction of such an instrument, and how such difficulties might possibly be overcome.

I do not propose to deal here with the optical difficulties, feeling quite satisfied that they can be successfully dealt with, if a disc of glass of sufficient size can be obtained; and if not, then by the use of speculum metal. Dr. Common, who has a most intimate knowledge of the difficulties to be overcome in making such large instruments, is of opinion that a silver-on-glass mirror of eight or nine feet aperture is now possible.

It is, however, to the mechanical difficulties of construction that I wish to address myself, as I believe, up to this time, this matter has not been very seriously treated. The problem is indeed one of enormous difficulty, and the working out of the details will be a serious matter.

Speaking generally, it may be taken that the whole weight of the tube, mirror and cell will probably be some forty or fifty tons, and in the present state of engineering skill it does not at first sight appear to be so very difficult to mount this on a simple universal stand, which will enable it to be pointed to all parts of the heavens. But such a mounting would be insufficient unless the telescope is to be used simply for getting transitory glimpses of celestial objects. It would be practically useless for all serious work, bearing in mind the requirements of the future ; for the chief hope of progress in astronomical research lies undoubtedly in the application of photography. It would appear to be not only useless (except to satisfy mere popular curiosity), but an absolute waste of money and energy to build an instrument of such large dimensions, unless its light-grasping power can be utilized for celestial photography.

The mounting must be of the equatorial form, and the problem to be solved is how to carry the enormous weights involved with all the *accuracy and delicacy* which are so essential for stellar-photographic work, while at the same time the instrument must also be readily available for general visual work. To satisfy the latter condition, it is necessary above all things, as has been pointed out by Dr. Common, that the eye-piece of the instrument should not be at any great distance from the centre of motion. This, in the ordinary Newtonian form, necessitates serious modifications, for there would have to be a considerable distance between the centre of motion and the centre of gravity of the essential parts. The telescope would thus be considerably out of balance, and dead-weight would have to be added to correct this. The instrument, no matter what its length and weight may be, must be carried as evenly and accurately as any of the smaller instruments specially constructed for stellar photography, and this may be expressed by saying that the pointing of the telescope must never be in error by an amount greater than the motion of a star in one-twentieth of a second of time.

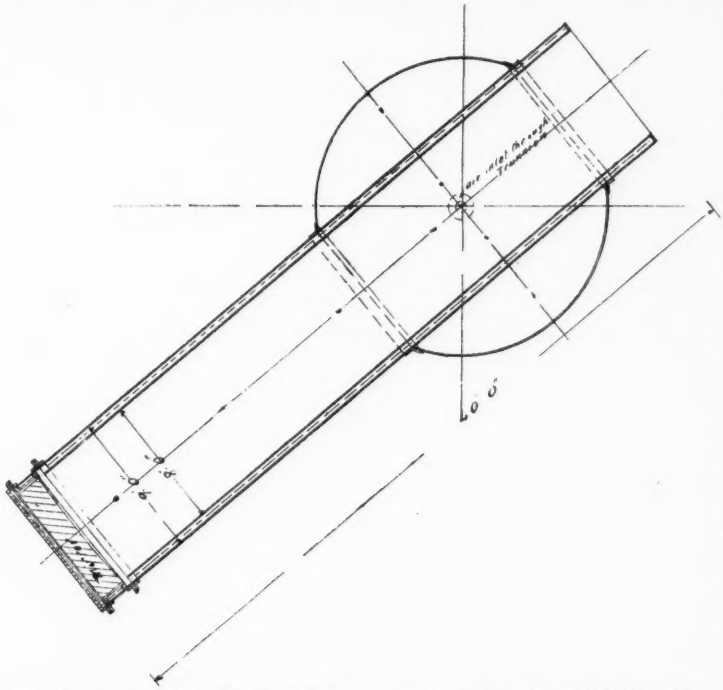

FIG. 1.—Section of the Telescope Tube, showing the double sides, and the direction of the air currents which will be produced by the fan or blower.

It was, no doubt, in view of the very great difficulties of fulfilling these conditions that Dr. Common was led to believe that it would be necessary to revert to the alt-azimuth form in mounting such large reflectors.

Now, when we consider that the lowest magnifying power of an eight-foot reflector is about four hundred and eighty, and of a ten-foot (such as is proposed for the next Paris Exhibition) six hundred, it will be understood how very unsatisfactory such a mounting would be for large-size telescopes.

To view objects in a telescope satisfactorily, it is necessary to bring them into or near to the centre of the field of view ; but even suppose we are satisfied to view them while in *any* part of the field of an ordinary eye-piece, the object could only be viewed in the eight-foot telescope for about fifteen seconds, and in the ten-foot telescope for twelve seconds at a time. This would render the instrument practically useless.

The larger the telescope the more important it is to have it equatorially mounted, and driven correctly by clockwork, so that the observer may watch for a favourable opportunity for distinct vision. It is to be remembered that, in the case of very large apertures, it is only in glimpses on a fine night that good definition is to be obtained ; and therefore it is all the more important that the observer should have the opportunity of watching for and taking advantage of these favourable moments.

I have ventured, in a paper read before the Royal Dublin Society on February 21st, to shadow forth what I believe will be the most hopeful principle on which to mount a monster reflecting telescope.

Dr. Common himself has made a splendid advance in adopting the system of flotation of the polar axis ; this principle of flotation appears to me to be capable of further development, and I have given some thought to the matter. It is perfectly possible to make a tube for a Newtonian reflecting telescope (which is necessarily closed at the lower end) of such a weight, and with its weight so distributed, that it will not only float submerged in water to a certain point (preferably near the upper end), but will be in a state of equilibrium when placed at any or in every position down to a certain angle, the angle depending on the exact outside form of the tube. For instance, Fig. 1 shows the tube closed at its lower end and perfectly symmetrical round its axis. The total weight of the tube must be equal to the weight of water which is displaced when the tube is sunk to the centre of the sphere; the weight of the different sections along the axis can be so distributed that the tube will equally well remain in any position, except it be so far turned over that the cylindrical part of the tube is lifted out of the water at one end and dipped at the other.

By making the spherical part of about the proportions of the figure, the tube can be depressed to within twenty-five degrees of the horizon, and still remain in perfect equilibrium.

Now suppose the tube to have a pair of trunnions attached at the water-line, and these to be carried on a polar axis of, say, the English type (see Fig. 2). We then

have an equatorially-mounted telescope of any size, without any weight whatever on the bearings of the declination axis; or, the tube may be lightened by an amount nearly equal to the weight of the polar axis, and there will then be practically no weight whatever on the bearings of that axis. So here we have a case of, say, an eighty ton telescope mounted and carried by an equatorial, but without throwing any weight whatever on the equatorial mounting; and the force necessary to drive the instrument is then independent of the weight of the telescope, and dependent only on the friction necessary to be overcome in carrying the tube at an exceedingly slow rate through the water.

The spherical protuberance of the tube being fixed near the upper portion, and the water-line being made coincident with the centre of the sphere, which is the centre of motion, it follows that the eye end of the telescope can be brought to within about fifteen feet of the centre of motion, and the movement of the observer need never be more than three feet per hour. To approach the eye end I would arrange a stage independent of the telescope, and mounted on rails round the tank shown in Fig. 2. Two flights of steps would enable the observer to be always within reach of the eye end.

To overcome the inconvenience to the observer due to the rotation of the tube as the telescope moves in right ascension I would perforate the circumference of the tube at intervals of thirty degrees, attaching adapters for eye-pieces at each place, and arrange the "flat-mount" in a collar, so that the flat could be turned through angles of thirty degrees, and the image of the celestial object to be observed would be thrown through the perforation of the tube which was most convenient for observation.

Let us inquire into any possible disadvantages that may be urged against this form of mounting :—

First—That the temperature of the water will often be different from that of the air, and consequently there will be a detrimental mixture at the mouth of the tube, of air from inside the tube (which will partake of the temperature of the water) and the cooler or warmer outside air.

This I would propose to avoid by making the tube double, with a space of some three inches between the inside and outside tubes, hermetically closed except at the lower end, where there would be apertures in the inside envelope.

The space between the two tubes would be connected through the trunnions with an air pump, worked by a gas or other motor, which would continually exhaust the air from between the two tubes, and thus cause a current of the outside air to pass continually down the inner tube and to the pump through the space between the two tubes. This would keep the temperature of the inside tube and the air in the tube constant with that of the outside air.

A velocity of motion of the air of one foot per second would perhaps be quite enough to entirely overcome this difficulty.

To avoid dewing of the mirror when the air outside was warmer than the temperature of the water, I would propose to warm the mirror by electric arrangements at its back, always keeping the mirror one degree above the temperature of the air.

Second—The limited range of the equatorial. I have stated that the instrument would be in perfect balance down to twenty-five degrees from the horizon. If desired, though no longer perfectly balanced, it can be used lower by employing a chain or wire rope connected between the lower end of the tube and the upper end of the polar axis, and the amount which the instrument would be out of balance, between twenty-five and twenty degrees, would be very trifling.

Again, it will not be convenient to use the instrument within some fifteen degrees of the pole. It could be planned to go somewhat closer, but when it is considered

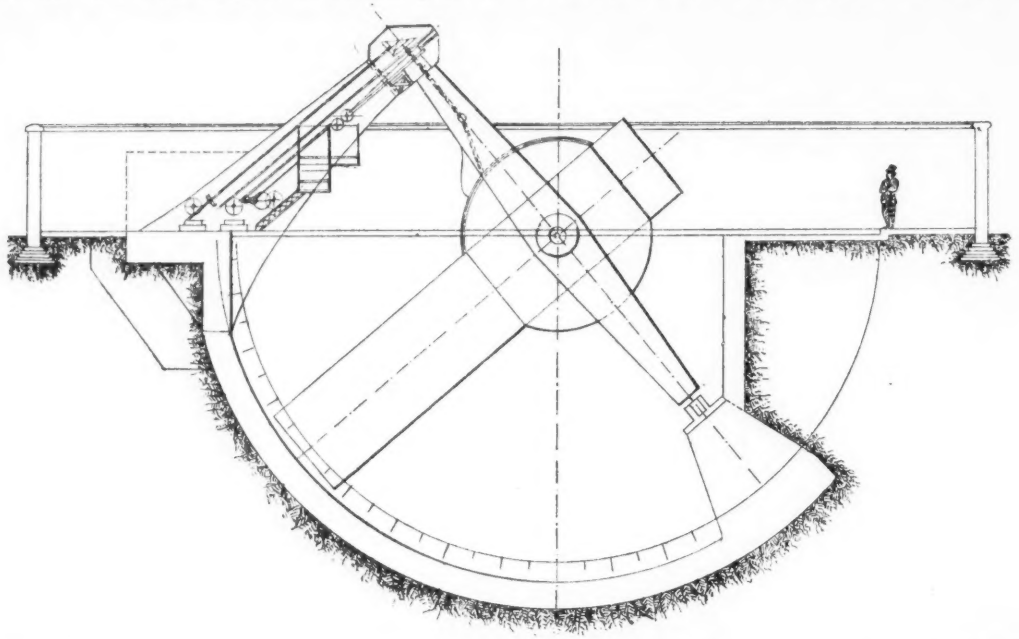

Fig. 2.—Section of the whole Instrument, showing the tube, polar axis and tank, together with the motors for producing the necessary motions.

that nine-tenths of the work required to be done can be commanded by this instrument, it is clearly better to design it to do that nine-tenths well than to strain it into motion in right ascension, one for the setting in declination, and the fourth instead of the usual clock for following the stars.

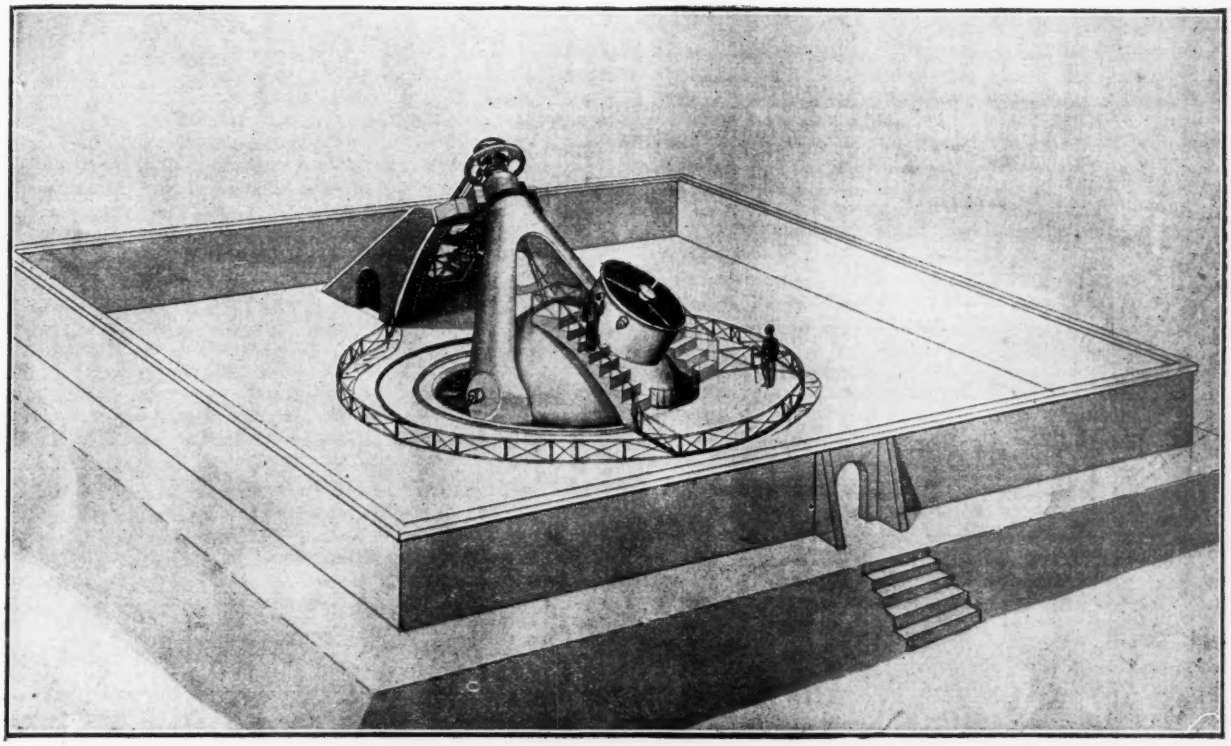

FIG. 3.—Perspective view made from the model of the proposed Instrument. It shows the movable gallery to which the steps are attached, by means of which the observer obtains ready access to the eye end.

doing another five degrees that would only be useful on very rare occasions.

Third—It may be urged that the friction of the water will prevent the rapid setting of the instrument.

In a telescope of this size all the motions would be effected by motors of some description, guided by the observer from a commutator board at the eye end, and there would be no difficulty in setting the telescope quite as quickly as could be expected considering its great size.

Fourth—It may be objected that currents will be set up in the water by the moving of the telescope, which currents will affect the steadiness.

No doubt this will be the case to some extent, but these will quickly subside, and the motion necessary for following the stars will be so slow that no perceptible effect of this kind will be felt from it.

I would make all the motions of the telescope and observing stage by electro-motors, controlled from a commutator board at the eye end of the telescope. A one-horse power gas engine would give all the power required to work this telescope. This could be fixed some distance from the telescope so as to avoid vibration. During observations it would be used to work the air pump, which would be either some form of fan such as the Blackman, or some blower like Root's or Beale's. During the day the gas engine would be used to charge storage cells for the motors, of which four would be required, all of them being under the control of the observer at the eye end. One motor would be required for the observing stage, one for the quick

STREAMS OF STARS IN THE MILKY WAY.

By A. C. RANYARD.

I AM indebted to Dr. Max Wolf, of Heidelberg, for the beautiful photograph which accompanies this note. It represents a very rich region of the Milky Way to the north of Sagittarius, and lies on the edge of the great dark rift which divides the Milky Way into two streams through about half its circuit round the heavens. The region photographed is not very far removed from the part of the Milky Way on the borders of the constellation Hercules, towards which the sun is drifting in space, certainly at the rate of ten miles a second. At such a pace, if the sun continues his course in a straight line and his motion is not disturbed by the attraction of some enormous mass of matter of whose existence we are at present ignorant, it will in the course of eighty thousand years have passed over a space equal to the distance separating us from α Centauri, our nearest neighbour amongst the stars. In a million years the sun will have passed over twelve and a half times that distance, and if this region of the Milky Way is twelve and a half times as distant as α Centauri, the larger stars shown in this photograph must be very large or very bright compared with our own sun.

The plate has been etched so as to show numerous streams of very faint stars whose images are not as dense and black as the images of the larger stars, and in bringing out these very faint objects it has been impossible to avoid

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showing a slight fogging and other small photographic defects, which are most evident near to the bottom of the plate. But the general nebulosity on the left hand of the plate—a nebulosity which is densest where the stars are most thickly distributed—represents true nebulosity as shown on Dr. Max Wolf's photographs.

The cluster near to the centre of the plate exhibits several radiating and branched streams of very faint stars somewhat similar to the branching streams which are shown radiating from the Hercules cluster in the photographs reproduced in KNOWLEDGE for June, 1893, but it must be remembered that this photograph is on a very small scale compared with the pictures of the Hercules cluster above referred to. I should like to draw the reader's attention to two curious undulating streams or strings of stars, which extend from the cluster towards the south or left hand side of the plate.

A somewhat similar series of curves of stars will be found about two inches higher up on the plate—that is, on the preceding side of the stream of stars trending to the south from the cluster in the middle of the plate. Fig. 1 shows them, and also shows a brighter line or

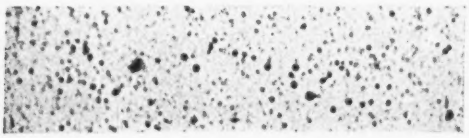

FIG. 1.—Triple Arch of Stars.

channel running alongside the strings of stars. There are several such bright channels or lanes (which on the sky mean dark channels) in the nebulosity, very distinctly traceable in Dr. Max Wolf's photographs, and also in those of Prof. Barnard. If these channels were due to a photographic defect, we should expect to find a nebulous band joining the star images of a stream of stars rather than a breach in the nebulosity lying on one side of the star stream. It is easy to conceive that, owing to imperfections of the optical image representing a star, the central spot of light might be surrounded by a nebulous haze, which in the case of a row of stars would merge together, and possibly in a photograph cause the stars to appear to be linked together by a nebulous band. But it is difficult to conceive of any optical reason for this reversed effect, especially as the brighter channels are not always coincident with or parallel to lines of stars.

I would invite the reader's attention to the curious small bright channels, as well as streams of faint stars, in the region of the plate reproduced in Fig. 2. It represents an area near to the top of the plate just below the beginning of the word "preceding."

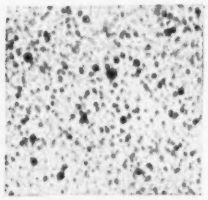

FIG. 2.—Curving Streams of Stars.

Some of the streams of fainter stars in this region are very striking, and must convince the most sceptical of their reality.

It is possible to draw an arc of a circle through any three stars, and a conic section through any five; but where we find ten or twenty stars falling into line, not once, but in many cases, and that there is a curious similarity between the strange curves and branching streams which these phalanges of stars mark out on the heavens, there is no room left for doubt that the mind is not being led away by a tendency of the imagination similar to that which finds faces in the fire, or sees a man carrying sticks on the face of the moon.

If it is proved that a group of stars is arranged in line or marshalled in any order, it would follow that the individuals of the group must be actually as well as apparently close to one another, and that they form some kind of system, having all of them had a common origin, or been subject to some common influence. What these streams and curves of stars mean, and what forces have marshalled them in lines, forms one of the grandest problems of the future, one that I trust I may live to see unravelled.

Science Notes.

Mr. Worthington P. Smith, in his new book, "Man the Primeval Savage," summarizes in a vivid chapter the surroundings and general appearance of the palæolithic men. The forests which then so extensively covered the British Isles harboured animals against which they had ever to guard; the lion, wild cat, bear, wolf, rhinoceros, and hyæna were among the most terrible to them, and the elephant, mammoth, hippopotamus, and bison were no doubt also to be feared.

From the bones that have been found it is noticeable that these earliest known men were shorter in stature, broader in the back, and less upright than the man of the present age; but it is not so clear how Mr. Worthington Smith has discovered that the hair which covered them was probably of a bright chestnut red. The forehead receded, and the heavy overshadowing brow-ridges suggest a creature but little removed from the arboreal ape in his habits.

Fear of their common enemies, those animals which would attack stray men who were isolated from their fellows and therefore helpless, obliged them to live in social communities, and to give one another aid and protection to some extent. But, reasoning from the condition of existing savages, Mr. Smith infers that the feebler among them were recognized by the rest as being useless to keep and unprofitable to provide for, so that if any one of their companions was badly injured by accident or attacked by disease, he was hunted away by the rest for the wolves to rid them of him, or deliberately killed.

Another marked resemblance to animal habits is seen in their apparent neglect of their dead, unless they burnt them; for if any deliberate burial occurred, it is singular no traces have survived. Possibly, as Mr. Smith hints, they were cannibals, and not only the dead but the weaker living among them became at times victims to the stronger. Their chief labour was the manufacture of their implements of flint, which were chipped out of the stones in the shape of knives, arrow heads, and such weapons. It is curious to notice that these were entirely fashioned by dexterous chipping, and this was a matter of considerable difficulty when the projected implement was to have a keen knife edge; the idea of rubbing one flake on another stone to produce a sharp edge did not occur to man till the neolithic time. These, with branches of trees cut as sticks, formed their only tools and weapons against wild animals. With such flint tools they could hunt only the smaller animals for food, but would possibly also devour the larger ones when they found them already dead.

At the last meeting of the Royal Meteorological Society, Mr. Inwards, the president, gave an account of various balloon ascents which had been undertaken with the object of making meteorological observations. In 1850 Messrs. Barral and Bixio, when they had ascended to twenty thousand feet, found the temperature had sunk to 15° Fahr., but this was in a cloud, and on emerging from it three thousand feet higher, the temperature fell as

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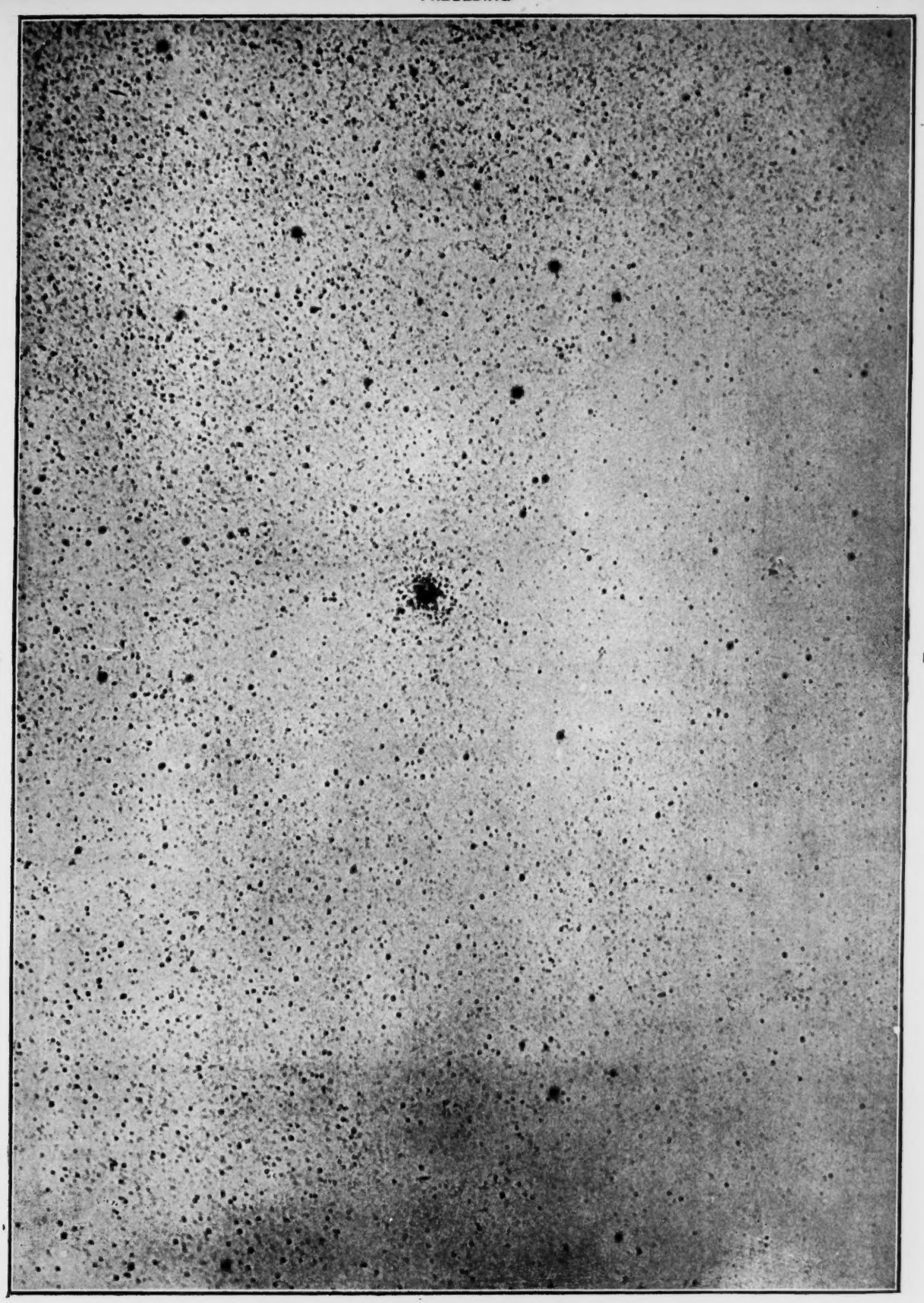

NORTH.

REGION OF THE MILKY WAY ROUND THE CLUSTER NEAR β SCUTUM SOBIESKI.

Enlarged from a Photograph taken by Dr. MAX WOLF, of Heidelberg, on the 28th July, 1892, with a camera of six inches aperture, by Voigtlander, and an exposure of three and a half hours.

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low as *minus* 38°, or 70° below freezing point. In 1862 Mr. Glaisher and Mr. Coxwell made their famous ascent, when they reached an altitude of about seven miles from the earth. A short time ago a balloon, without an aeronaut, but having a set of self-recording instruments attached, was sent up in France, and from the records obtained it is shown that a height of about ten miles was attained, and that the temperature fell to *minus* 104° Fahr.

Clouds are simply a form of water made visible by the cooling of the air which previously held the water in the form of invisible vapour. Every cloud may be regarded as the top of an invisible warm column or current thrusting its way into a colder body of air. The comparative altitude of a cloud may be judged, when there is no time or opportunity to make exact measurements, from its form and outline, its shape or shadow, its apparent size and movement, its perspective effect, and the length of time it remains directly illuminated after sunset. By the last method Mr. Inwards states that some clouds have been estimated to have been at least ten miles above the surface of the earth. The cloud velocities at high altitudes have been carefully noted at the Blue Hill Observatory, Mass., U.S., and show, practically, that at about five miles in height the velocities are three times as fast in summer and six times in winter as the velocities of the currents on the earth's surface.

Dr. Hume, in his thesis for the Doctorate of Science, has given geologists a minute and exhaustive account, chemical, mineralogical, and biological, of the zones of the upper Cretaceous in the south of England. With regard to the vexed question of the origin of the chalk, so interesting in its bearing upon the permanence of the great oceanic troughs, Dr. Hume is of opinion that the organic remains point to an ocean which, if not abysmal, was at least far deeper locally than many prominent marine areas. The opinion which M. Cayeux formed from a study of the minute derived minerals in the chalk, that this rock is after all a shallow-water deposit, is contested by Dr. Hume, and he hints not obscurely at ice and ocean currents to explain the mineralogical difference between the chalk detritus and the corresponding constituent of the globigerina ooze now accumulating in the Atlantic.

INSECT SECRETIONS.—I.

By E. A. Butler, B.A., B.Sc.

As a group, insects are remarkable, when compared with the other great divisions of the animal kingdom, for the number and variety of the secretions they produce, whether it be for protection against their numerous enemies, or for constructive or other purposes connected with their own economy. Not only are these secretions useful adjuncts to the creatures from which they emanate, but they are also the source from which most of the valuable products obtained by man directly from the insect world are derived. Such materials as wax, silk, lac, cochineal, all of which are of the nature of secretions, will at once occur to the mind and serve to exemplify the variety mentioned above, and the commercial advantage that may accrue when man can take under his own control the wonderful secreting power of these little beings. But these four products, though amongst the chief of what we have found it profitable to employ for our own purposes, and therefore by far the best known are but a very small proportion of the multitude of substances secreted by insects; and we propose in the present series of papers to try to give some idea of the immense number and variety of these products of insect vitality. The subject will open up, to such of our readers as possess the requisite qualifications and care to pursue the inquiry, a wide field of investigation, for in many cases but little is known of the exact composition of the substance secreted, and the discoveries of the last few years have shown that in all probability many more exist than are yet known or even supposed.

It may be premised that such secreted substances as we are here speaking of will, in their primitive condition, be liquids, though these may afterwards, when stored or brought into actual use, either solidify or vaporize; and further, that the presence of a secretion implies the existence of a special apparatus for the purpose of elaborating it. To this apparatus the general name of "gland" is applied, whatever may be its exact structure. To constitute a gland, all that is essential is a cell, or a group of cells, which shall have the power, under nervous stimulus, of elaborating from the materials with which they are supplied the secretion in question. There will in most cases also be some means by which the secretion, when formed, can be conveyed to the spot where it is required, and this will frequently be in the form of a tube or tubes called "ducts." There may also be superadded to these parts a storage reservoir, especially when the secretion, though tolerably constant in its formation, is used only at intervals. Of course such substances as bile, saliva, &c., which occur in many groups in the animal kingdom, are of the nature of secretions, but we do not propose to deal here with such as are common to many classes of animals, but only with those that, with one or two slight exceptions, are characteristic of the class Insecta. These secretions are not confined to any particular group of insects, and in fact, of all the eight or nine orders into which the majority of insects naturally fall, not more than one or two will be omitted from our enumeration as being of insignificant importance in this direction. By far the most extensive group thus excluded is the order Diptera, or two-winged flies, to which we look in vain for any noteworthy secretions of the kind we are speaking of. Even the formation of silk, which is so common amongst other insects with a complete metamorphosis, is practically absent from this order. One good reason for this will readily occur to the mind. One of the chief uses of silk to insects in general is to protect them in their helpless pupal condition; but a large number of the flies, it will be remembered, form their chrysalis inside the last larval skin, which hardens into a barrel-shaped receptacle, the whole structure thus formed going by the name of "puparium." Thus the chrysalis, being already protected by the hard barrel-like skin of the larva, requires no other envelope, and the silk-forming power is consequently absent.

In silk we have the chief secretion which is shared by animals outside the limits of the class Insecta; spiders, in making receptacles for their eggs (Fig. 1) (the so-called cocoons), and in building up their snares, use a gummy secretion drawn out into a fine thread, which is sometimes scarcely distinguishable from the silk of insects. The silk of which their egg-cases are formed is most like that of insects, as is evidenced by the application of the term "cocoon" to them, though they shelter eggs and not pupæ. The silk of which the

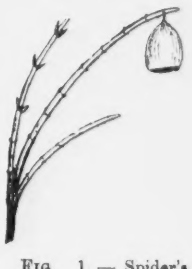

Fig. 1. — Spider's cocoon suspended from twig.

snares are made is less like that of insects, inasmuch as it remains more or less viscid after exclusion, while insect silk hardens at once on exposure to the air. If the silk of spiders' webs did not retain its viscosity, it would be of little use for entrapping victims to supply the larder; and, on the other hand, a permanent viscosity in the silk of cocoons, whether the egg ones of spiders or the chrysalis ones of insects, would be a drawback rather than an advantage, as the cocoon would become encumbered with rubbish which would adhere to it, and consequently we find no such property developed in this connection. The position of the silk glands, too, is quite different in spiders from what obtains in insects. In the former they are situated in the abdomen, and the silk issues from innumerable minute orifices situated on papillæ under the tail end of the body; whereas the silk glands of insects are placed in the anterior part of the body, and the ducts open by a single orifice on one small papilla just beneath the lower lip and outside the mouth.

Early in the last century, Réaumur made some inquiries as to the comparative value of the silk of spiders and that of silkworms for manufacturing purposes. The inquiries were suggested by the achievement of a certain M. Bon, of Languedoc, who had succeeded in making stockings and mittens of spider silk. Réaumur found that the thread of the spider's cocoon had about eighteen times the strength of that of the web, and further, that it would take about five of the spider's strongest threads to equal one of the silkworm's. He calculated also that it would require nearly thirteen times as many spiders as silkworms to make the same amount of silk, and since only the cocoon silk would be available, of course all of these must be females. The superiority of insect silk was thus unmistakably demonstrated; while the further difficulty, that the natural ferocity of spiders rendered it impossible to keep large numbers of them together, put the idea of profitably using their silk out of the question.

We have already pointed out that the power of secreting silk is possessed by insects in their larval state only, the glands by which it is secreted being aborted in the adult. The commercial importance of the silk derived from the Chinese silkworm leads us, no doubt, to mentally associate silk most closely with the caterpillars of moths and butterflies, but its production is not confined to the order Lepidoptera, though what is produced by insects outside that order has no commercial value. Amongst the Hymenoptera, for example, we find saw-flies and ichneumon flies making cocoons just as successfully as any lepidopterous insect. The larvæ of some ants also make a silken cover within which to become pupæ, and those of bees and wasps cover the entrance to their cells with a silken cap, so that they may pass into their resting condition undisturbed. Some beetles, too, make neat little network or papery cocoons, which are attached to the food-plant. The caddis worms, again, which are the larvæ of caddis-flies, members of the order Trichoptera, line their curiously-constructed cases with silk, so as to form a smooth and comfortable chamber. The same material is used to fasten together the shells, grains of sand, bits of stick, or dead leaves by which the case is ornamented outwardly, as well as to make the grating by which the end of the case is guarded when the enclosed insect becomes a pupa. Lastly, even the common flea envelopes itself in a little silken ball when it changes from a wriggling maggot into a restful, dumpy chrysalis. Thus we see that the power of secreting some sort of material to which the name "silk" may fairly be applied is found in at least four orders, though in only three of them is it widely prevalent.

As one of the chief uses of silk is to construct cocoons for protecting the chrysalis, silk glands must not be expected to be present in insects whose metamorphosis is incomplete, and in which there is no such thing as a chrysalis; so that to dragon-flies, grasshoppers, crickets, earwigs, bugs, &c., silk spinning is an unknown art. And as we have seen, even amongst those insects whose metamorphosis is complete, there are many that pass through their changes without the assistance of silk. It is unquestionably in the order Lepidoptera that the silk glands reach their highest perfection, and here the uses of the secretion are manifold. Many larvæ of moths hang suspended by a silken thread when suddenly shaken from the trees on which they are feeding; others construct shelters by fastening leaves together or building fixed galleries or movable tubes, while social caterpillars employ their silk to fabricate a nest which all may use in common. There is a curious little moth which is a great pest in chocolate warehouses, and which, living in enormous swarms together, sometimes covers the whole of a wall with a thin sheet of silken webbing to facilitate the movements of the members of the colony. The same secretion, too, helps to bind together the cocoa-nibs, and prevent them from shifting as they become disturbed by the ravages of the insects. It is of this destructive pest that Curtis speaks in his "Farm Insects," when he draws the following horrifying picture: "I have known bushels of cocoa-nuts which were, every one, worm-eaten and full of maggots, with their webs, excrement, cast-off skins, pupæ, and cocoons, all ground down to make chocolate, flavoured, I suppose, with vanilla."

Should a caterpillar wish to change its skin, it will often spin a little raft of silk upon a leaf to serve for foothold for the "claspers," while it crawls out of its old skin through a slit in the neck. The hooks with which the claspers are furnished being inserted firmly amongst the meshes of the silken structure, a position of vantage is gained, and the creature can use all its strength to pull itself out from its old skin, which will be left collapsed on the raft. And then, when the pupating time comes round, the results of the use of silk are of the most varied description. In some cases a distinct cocoon is made, smooth and even inside, and more or less rough outside, either white or of some shade of yellow or brown, the texture varying from that of a thin and brittle papery film, or a hard and chippy layer in which no threads can be traced, to the loosest possible network of distinct threads. If the caterpillar adopts a subterranean retreat, either a cell is excavated in the loose earth, and the fragments of soil in its walls cemented together by silk, or a complete and tough silken lining is made, which easily comes away from the surrounding earth when it is dug up. Such subterranean cocoons may often be found round the roots of trees, especially where the soil is bare and affords easy ingress to the burying caterpillars.

A third method of utilizing the silk for pupation is to be met with amongst the larvæ of butterflies. These insects are very chary of their silk, expending an exceedingly small quantity of it on their pupating arrangements, and rarely making even so much as a loose web. Sometimes there is merely a small button of silk to serve as a support for the tail of the chrysalis, which thus hangs head downwards from the underside of a leaf or a ledge of some sort. The beautiful butterflies known as *Vanessidæ*, and popularly called tortoiseshells, admirals, peacocks, &c., pupate in this way, as also do the lovely spotted fritillaries. The process of suspension by the tail is a difficult one, and is carried out in a remarkable fashion. The button of silk is first formed, the caterpillar laying down layer after layer, each one over a smaller area than

the preceding, so that a conical mass is formed. Then the hooks of the last pair of prolegs are entangled in the mass, and the caterpillar swings down into a vertical position. It has now to cast its skin, in order to appear as a chrysalis. The head is bent round in a curve and after a while the skin splits along the back, and the contained chrysalis appears through the opening. By various contortions it manages to push the old skin gradually backwards towards the point of suspension. The tail of the chrysalis is not yet attached to the support, though the old skin is; but before the skin is pushed quite off, it is necessary for the chrysalis to secure itself. This it does by working itself gradually upwards by means of the still partially investing skin, and stretching out its tail till it can reach the button of silk. The tail is provided with a large number of hooks (Fig. 2), and by means of these the chrysalis fastens itself to the silk, and hangs securely while the skin is completely pushed away.

Fig. 2.—Hooks at end of chrysalis of Red Admiral Butterfly.

The white butterflies and their allies, as well as the swallow-tails, make a more elaborate arrangement. For some reason or other, they elect to lie parallel to the surface of support instead of hanging freely suspended. They therefore add to the tail button a thin loop round the anterior part (Fig. 3), fastened on each side to the object of support, but not in any way adhering to the chrysalis, which therefore lies free in the loop. The loop is made either by the caterpillar bending backwards and running its threads from side to side over its body, or by constructing the loop first and afterwards getting into position.

Fig. 3.—Chrysalis of Swallow-tail Butterfly, suspended by button and loop.

The ancients were sorely puzzled as to the origin of the silk of commerce. For many centuries it reached Europe only as a raw product, or a manufactured article coming from the East, where it was cultivated, a region which to an average European might as well have been, for aught he knew about it, in another world. Thus, never having seen the thing in its natural condition as produced by the silkworm, they trusted to rumour for the explanation of its origin, and, as usual, rumour grotesquely mangled the tale as it travelled from mouth to mouth many times over. Silk had some sort of connection, it was understood, with the animal kingdom and some with the vegetable, but what was the precise share of each was by no means clear. Certain insects and trees had a kind of partnership in its production, but only the vaguest notions were current in many places as to the sort of insects and trees that were between them responsible for the lovely product. Perhaps we cannot do better, in order to show the absurdity of the ideas held on this subject even by educated people some eighteen centuries ago, than quote a passage from the naturalist Pliny, who flourished during the golden age of Latin literature; and as the crudity of the ideas will find a better match in an antique English version than in the literary language of the nineteenth century, we will adopt the rendering of an old translator. The passage is as follows: "They build their nests of earth or clay, close sticking to some stone or rock, in manner of salt; and withall so hard, that scarcely a man may enter them with the point of a spear. In which they make also wax, but in more plenty than bees; and after that, bring forth a greater worme than all the rest before rehearsed. These flies engender also after another sort namely, of a greater worme or grub, putting forth two hornes after that kind: and these be certain canker-wormes. Then these grow afterwards to be Bombilii, and so forward to Necydali: of which in six months after come the silke-wormes Bombyces. . . . . It is commonly said, that in the Isle Cos there be certain silkwormes engendered of flowers, which by the meanes of rain-showers are beaten downe and fall from the cypres tree, terebinth, oke and ash; and they soon after doe quicken and take life by the vapor arising out of the earth. And men say, that in the beginning they are like unto little butterflies, naked, but after a while (being impatient of the cold) are overgrowne with haire; and against the winter, arme themselves with good thick clothes; for being rough-footed, as they are, they gather all the cotton downe of the leaves which they can come by, for to make their fleece. After this, they fal to beat, to felt and thicken it close with their feet, then to card it with their nailes; which done they draw it out at length, and hang it betweene branches of trees, and so kembe it in the end to make it thin and subtill. When al is brought to this passe, they enwrap and enfold themselves (as it were) in a round bal and clew of thread, and so nestle within it. Then are they taken up by men, put in earthen pots, kept there warme, and nourished with bran, untill such time as they have wings according to their kind; and being thus well-clad and appointed, they be let go to do other businesse."

With such a ridiculous collection of nonsense had the *élite* of Roman society to be content, if they wished to know anything of the origin of the soft and brilliant fabrics which they so much prized as a novel article of clothing. It is plain that the author writes simply from hearsay, and has jumbled up together notions derived from different insects and embellished them with freaks of the imagination. And yet there was nothing so very extraordinary in the production of silk by silkworms. The counterpart of the process was going on every season in wild nature in hundreds of places in the country districts all round the Western folk as well as in the remoter regions of the far East; and one would have thought that they might have recognized enough resemblance between the cocoons of the wild Lepidoptera of their own regions and the silk of commerce to have made a nearer guess at the origin of the latter, had they but had eyes to observe more carefully what was going on in the woods and fields close to their own doors. Another account was even more ludicrous, for it was gravely stated that silk was the entrails of a spider-like creature which was fed for four years on a kind of paste, and then with willow leaves, till it actually burst with fat.

The silk-glands of the silkworm are, as might be expected, exceedingly well developed, and may be taken as the type of the organs for the order at large. On opening the body of a silkworm, the glands may be seen as twisted tubes lying partly by the side of, and partly underneath the stomach. Each consists of three parts. The central, which is the most prominent, is a stout, yellowish tube, bent into folds; this is prolonged behind into a much-twisted but narrower tube, and in front into a very fine straight one. The straight tubes of the two glands unite to form a common canal, which leads to the spinneret or papilla placed beneath the mouth. The gummy secretion which is elaborated in the lower divisions of the glands passes as fine threads into the common canal, where another secretion from small glands at the sides unites the two threads into one, at the same time giving the combined

thread the beautiful gloss which is one of its strongest attractions; and finally, the composite fibre thus made issues at the pore of the papilla and speedily hardens. In forming the more compact portion of the cocoon, the caterpillar, which is of course inside at the time, bends its head over its back and sways it backwards and forwards, tracing out with its silk a series of figures of eight which adhere to one another by reason of the stickiness of the thread when fresh formed. When a patch of silk has thus been laid down in one position, another is similarly placed elsewhere, and so on till the cocoon acquires the requisite thickness all over. The amount of silk used depends upon the amount and nature of the food on which the insect has been reared. Sometimes as much as half a mile of silk may be unwound from a single cocoon, and it is easy to see what a vast amount of work the laying down of such a length entails upon the caterpillar, and what an enormous number of times it must sway its head backwards and forwards through the narrow limits of its silken envelope before its toils are over.

(To be continued.)

ANCIENT AND MODERN HIPPOPOTAMI.

By R. Lydekker, B.A.Cantab.

THE popular conception of hippopotami is that they are clumsily-built creatures of enormous size and bulk, spending the greater portion of their time in the rivers and lakes of Africa, where they are more at home than on land, diving with the readiness of a crocodile, and even walking on the river bed with their bodies submerged many feet below the surface of the water. As regards the common hippopotamus (*Hippopotamus amphibius*), which is the one that has alone been exhibited in our Zoological Gardens, and portraits of which we are enabled by the courtesy of the Secretary of the Zoological Society to present to our readers, this conception is a perfectly true one. As, however, is so frequently the case in popular zoology, this conception, excellent as it is so far as the common species is concerned, does not cover the whole ground, for it happens that there exists in Liberia a second species of the genus, known as the pigmy hippopotamus (*H. liberiensis*), differing not only in size, but likewise in habits from the one with which we are all familiar. In place of attaining a total length of about eleven feet, measured in a straight line, and weighing probably some three or four tons, the pigmy hippopotamus is not larger than a good-sized wild boar, although it has the short and stout limbs of its gigantic cousin, with which it also agrees to a certain extent in the relatively large size of its head. As regards its mode of life, this species differs, however, *in toto* from the common one. Instead of passing at least as much of its time in the water as on land, and never living away from rivers or lakes, the pigmy hippopotamus is an inhabitant of the dense tropical forests of that part of western Africa which is its home, where it apparently leads a life very similar to that of wild pigs, wallowing in swamps after the manner of those animals, but apparently not habitually frequenting rivers, though it is doubtless, like almost all mammals, able to swim well when the necessity arises. Moreover, in place of associating in large herds after the manner of the common species, and never moving far from one particular locality, the Liberian hippopotamus is a comparatively solitary creature, going about at most only in pairs, and wandering long distances through the woods, where it seems to have no definite place of abode.

Out of a large number of representatives of the genus once widely spread over the Old World, the common and pigmy hippopotami, both of which are confined to Africa, are the only species which have survived to the present day; and the reader will at once see, when we have to take into consideration the probable habits of the extinct kinds, how fortunate it is that these two widely different forms have been preserved to us. Were there only the common species, we should have had no conception that any hippopotamus possessed the habits characterizing the smaller kind, and might thus have been led into drawing very erroneous inferences as to the mode of life and habitat of fossil hippopotami.

The general appearance of the common hippopotamus is so familiar to all, and is so well portrayed in our illustrations, that we need not spend much time in discussing it. We may observe, however, that the enormous size of the head, and especially the great width of the mouth, the prominent position of the eyes and nostrils, the minute ears, bulky body, short and stout limbs, and short tail, are among the most striking external features of the creature. The presence of hoofs (four in number on each foot) shows that the hippopotamus belongs to the great order of hoofed, or ungulate, mammals, and the thickness of its nearly naked hide led the older naturalists to place it among what used to be called the pachyderms. It has been shown, however, by anatomical investigations that the group thus designated, which included such totally different forms as elephants, rhinoceroses, and hippopotami, is an entirely artificial one, and that hippopotami, together with their near relatives the pigs, are much more closely connected with the ruminants, the distinctive characters of which have been already indicated in an article in this journal.

The young hippopotamus represented in the full-page plates was born in Antwerp in September, 1891; while the large female depicted in our third and fourth illustrations is of English birth, having been born in the Zoological Gardens on November 5th, 1872, and accordingly named "Guy Fawkes." In both instances, Mr. Ranyard, by whom the photographs were taken, has been successful in showing the characteristic form of the head.

If the reader desires to know why zoologists place such very dissimilar-looking animals as the hippopotamus and the giraffe in the same great group, while they sunder from the former the apparently more similar rhinoceroses, we reply that this is largely due to the difference in the structure of the feet of the two groups. In that the bones of the skeleton of the two middle toes are symmetrical to a line drawn between them, the hippopotami and pigs resemble the ruminants, whereas the rhinoceroses agree with horses in having the middle toe (which is alone present in the latter) symmetrical in itself. Those of our readers who read the article above referred to may recollect that one of the essential characteristics of the ruminants is the circumstance that in the lower part of the leg the two middle toes are supported by a single bone known as the cannon-bone, which consists anatomically of two originally distinct elements welded together, while the supporting bones of the small lateral toes are incompletely developed. If, on the other hand, we examine the skeleton of a hippopotamus, we shall find that in each foot the four nearly equal-sized toes are severally supported by four complete and distinct bones, known in the fore limb as the metacarpals and in the hind limb as the metatarsals; and it will be obvious that this is a much simpler or generalized type of foot-structure than that which characterizes the ruminants. If, again, we contrast the foot of a hippopotamus with that of a pig, we

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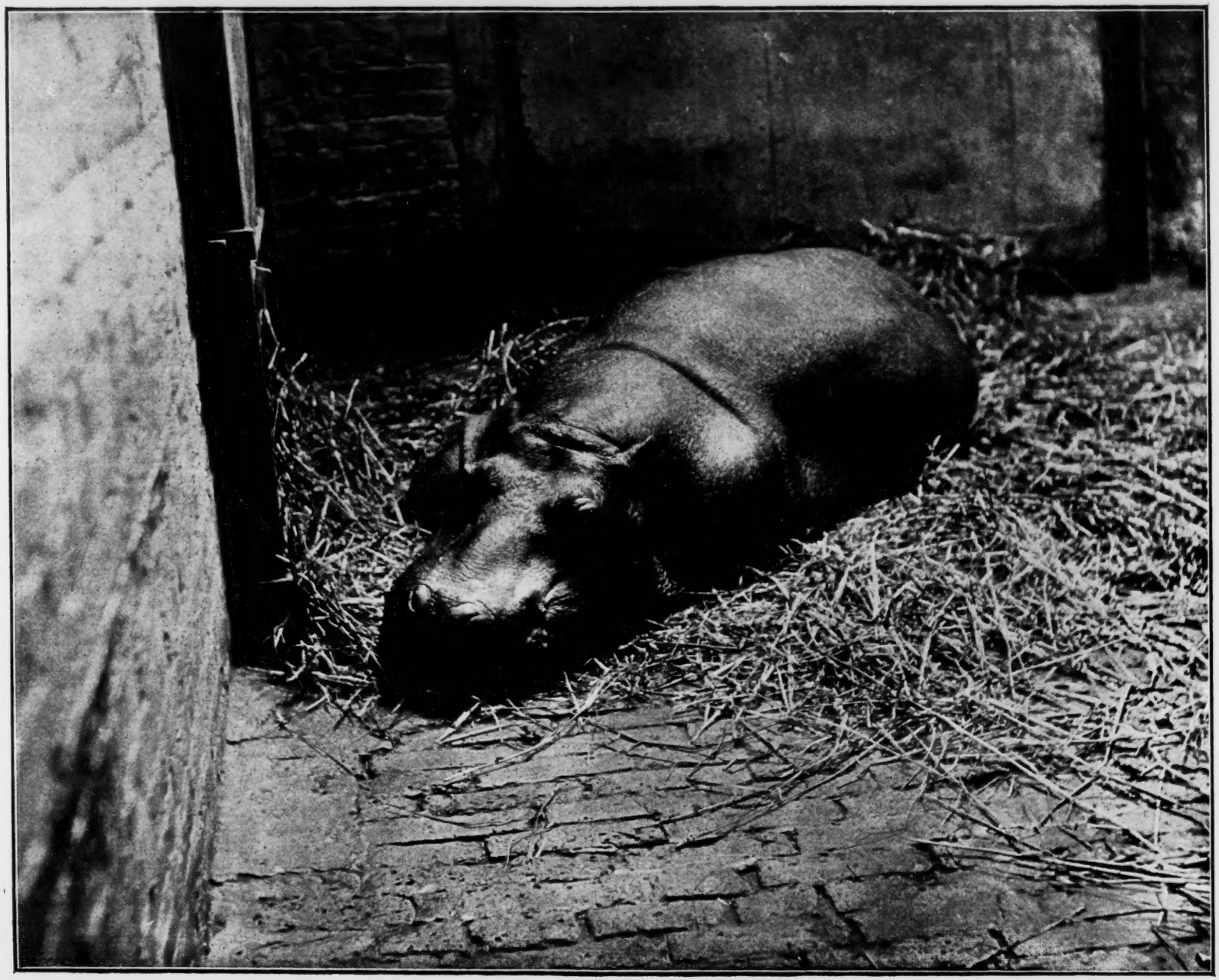
Born at Antwerp in September, 1891; now in the Gardens of the Zoological Society, Regent's Park, London.



SIDE VIEW OF YOUNG MALE HIPPOPOTAMUS.

Born at Antwerp in September, 1891; now in the Gardens of the Zoological Society, Regent's Park, London.

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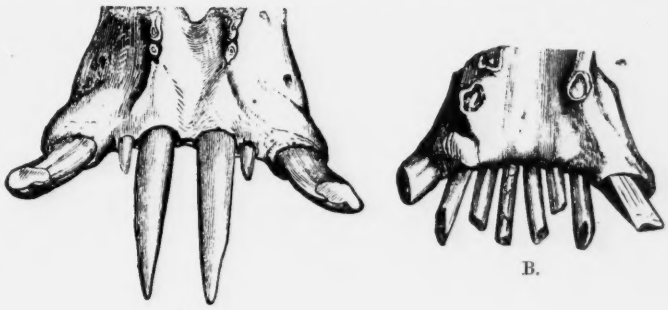
shall find that whereas in the latter the lateral pair of hoofs are considerably smaller than the middle pair and do not touch the ground when the animal is walking on a hard surface, in the former the two pairs are nearly equal in size and are all applied to the ground in walking. In this respect the hippopotamus is the most primitive of all the even-toed hoofed mammals that have survived to the present day, and is, therefore, a creature of special interest to the believer in evolution. It is, indeed, a member of the great group from which the ruminants are considered to have originated; although, if the reader should be led from this statement to jump to the conclusion that a hippopotamus was in any sense an ancestor of the giraffe, he would be led into a grievous error. As is the case with nearly all existing animals of a primitive type, the hippopotamus, in place of being an ancestral form, is a side-branch from the original stock, which has developed certain specialized features not found in the latter. To show that this is the case, we have but to study the teeth of the various species of hippopotami, which are of such a nature as to show conclusively that those of the ruminants could not have been derived from them.

It will be remembered that in the group of animals last mentioned the molar teeth have crescent-shaped columns on their grinding-surfaces; and those of our readers who recall an article which appeared some years ago in KNOWLEDGE under the title of "Teeth and their Variations,"* may recollect that extinct animals show a complete passage from such teeth to a simple type not unlike that now found in the pigs. The molar teeth of the hippopotami, though of the same general plan as those of the latter, have, however, their four main columns, when partially worn, with a distinctly trefoil-shaped pattern; and it is quite evident that such a tooth could never have given rise to the crescent-teeth of the ruminants. The hippopotamus molar is, indeed, quite peculiar, and its structure is is so well marked and characteristic that any person who has once seen a figure like the one here given could immediately identify any example that might come under his notice.

FIG. 1.—Molar Tooth of Hippopotamus, showing the trefoil-shaped surfaces on the crown. Actual size.

Whereas, however, all the members of the genus have molar teeth almost exactly alike, there is a considerable amount of difference with regard to the front or incisor teeth of the different species, and as these differences are of considerable interest from an evolutionary point of view, they may be considered in some detail.

In the first place, it may be mentioned that all hippopotami have an enormous pair of curved tusks or canines in each jaw, these being shown on the sides of the two lower jaws represented in our second figure. In the common species, between these huge tusks are two pairs of incisors, those of the upper jaw being of nearly equal size, whereas in the lower jaw, where these teeth are cylindrical and project nearly horizontally forwards, the central ones are very much larger than the lateral pair, as shown in Fig. 2 (A). If, however, we examine the lower jaw of the pigmy Liberian species, we shall find that normally there is but a single pair of incisors between the tusks, which would lead to the conclusion that this animal is a more specialized type than its larger relative. The truth of this inference is curiously confirmed by the circumstance that individuals of the Liberian hippopotamus are occasionally met with in which there are two incisor teeth on one side, while on the other there is but the single tooth; this being an excellent example of what evolutionists term reversion or atavism. This, however, by no means brings us to the end of the variation in the number of these teeth obtaining in the group under consideration; but before proceeding further it is necessary to remark that, since in ordinary mammals the typical or full complement of incisor teeth consists of three pairs, it is natural to suppose that one pair has been lost in the common species. That such is really the case is demonstrated by the extinct Siwalik hippopotamus (*H. sivalensis*) of the Pliocene deposits of the outer ranges of the Himalaya, of which the extremity of the lower law is shown in Fig. 2 (B). Here it will be seen that between the two large tusks there are three pairs of incisor teeth, which differ from those of the common species in being all of nearly equal size; and if we were to examine the upper jaw, we should find that in this also there is the same number of teeth. In the presence of these three pairs of incisors the Siwalik hippopotamus resembles the pig, from which it departs less widely than does the common species in that these teeth are relatively smaller and also of nearly equal size. The Siwalik hippopotamus must accordingly be regarded as a less specialized species than either of its living cousins; and since, together with an allied species from the Irrawady valley known as the Burmese hippopotamus (*H. iravaticus*), it is the oldest representative of the genus, its generalized features are precisely what evolutionary considerations would have led us to expect.



A. B.

FIG. 2. — Extremity of the Lower Jaw of the Common (A) and Siwalik (B) Hippopotamus.

There is, however, yet another curious point in connection with these teeth demanding a moment's notice. From the evidence of the two specimens represented in Fig. 2, it is quite impossible to determine which of the three pairs of lower incisors found in the Siwalik hippopotamus have disappeared in the common species.

* Reprinted in "Phases and Forms of Animal Life." Longmans & Co.

Fig. 3.—Front view of full-sized female Hippopotamus, born 5th November, 1872, in the Zoological Gardens, London.

Fortunately, however, palæontology here once more comes to our aid, showing not only which pair has been lost, but how the loss was brought about. From the gravels of the Narbada Valley in central India, which are probably intermediate in age between the Pliocene deposits yielding remains of the Siwalik hippopotamus and the brick-earths of our own country in which occur those of the common African species, there are found two extinct members of the genus, one known as the Narbada hippopotamus (*H. namadicus*), and the other as the Indian hippopotamus (*H. palæindicus*). In the former of these the lower incisors are similar in size and number to those of the Siwalik species; but in the latter, while the inner and outer pairs are very large, there occurs on each side between them a minute and rudimentary tooth, squeezed out from the general line to the upper margin of the jaw, and evidently just about to disappear altogether. We have thus decisive evidence that the missing pair of lower incisor teeth in the common hippopotamus is the second; and we further see how a complete transition can be traced, as regards the number of these teeth, from the Siwalik species through the common one to the Liberian hippopotamus. While it is quite possible that the African hippopotamus may have been directly derived from the Siwalik species, it is quite clear that the pigmy hippopotamus is not the descendant of its giant existing cousin.

With regard to the geographical distribution of the genus, we have already said that the two living species are confined to Africa, to which it may be added that there is no record of their having ever occurred in the districts lying to the north of the Sahara during the historic period. They are, therefore, essentially inhabitants of what naturalists term the Ethiopian region, although they are quite unknown in the island of Madagascar, which belongs to the same zoological province. So far as we are aware, there is no evidence that the pigmy species ever ranged beyond its present habitat of Liberia, although the case is very different with regard to the range of the common species. At the present day this animal is found from the Cape Colony northwards to the cataracts of the Nile, and it extends westwards to Senegal; but while for several centuries it has been very seldom met with on the Nile below the entrance of the Atbara and Blue Nile, there is abundant evidence that in the time of the Pharaohs it was common in Egypt, where in the temple of Edfu, as well as several other buildings, there are frescoes representing the mode in which it was hunted and speared. That the hippopotamus is the animal indicated in the book of Job under the name of behemoth is, according to Canon Tristram, undoubted, but there is no evidence that the Jews were acquainted with it otherwise than during their sojourn in Egypt. It is true, indeed, that the writer just mentioned suggests that its range may have extended eastwards as far as Palestine, but this is mere conjecture, and had the creature ever lived there the expeditions which have from time to time explored that country ought to have found some of its remains. In the Pleistocene and upper Pliocene deposits of southern and central Europe there occur, however, numerous remains of a hippopotamus which cannot be specifically distinguished from the existing African form, although it was generally of rather larger size. This difference in size was at one time thought to indicate that the fossil form was a distinct species, but the discovery many years ago of a half

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FRONT VIEW OF BABY HIPPOPOTAMUS.

Two and a half years old, now in the Zoological Gardens; showing the small size of the ears, the prominence of the eyes, and the slit-like nostrils, the latter being nearly closed.

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fossilized jaw in the alluvium of the Nile near Kalabshi, in Nubia, showed that in former times the African hippopotamus attained dimensions as large as the European form. In England the hippopotamus ranged at least as far north as Leeds, and it is a remarkable circumstance that in many places its remains have been found in association with those of the reindeer. How animals now inhabiting countries with such totally different climatic conditions as tropical Africa and Lapland could have lived in the same country at the same time, is very difficult to understand. If the hippopotamus had been different from the living African one, we might have regarded it as a terrestrial species like that of Liberia, and thus perchance capable of standing a colder climate; but being identical with the former, we are perforce compelled to believe that its habits were similar, and that in its habitat the rivers must have been more or less free from ice throughout the year. Whatever may be the true explanation of the difficulty, it is pretty clear that no theory of summer and winter migrations will hold good, as the hippopotamus is essentially a resident animal.

Returning once more to Africa, we may notice that in Algeria, where the genus is now unrepresented, a small species (*H. hipponensis*) flourished during the Pleistocene period; this species being distinguished by having three pairs of lower incisor teeth, which differed from those of other members of the genus in having their enamel smooth and their extremities somewhat expanded, thus approximating to the corresponding teeth of the pigs. Equally noteworthy is the occurrence of another species, Lemerle's hippopotamus (*H. lemerlei*) in Madagascar, where its remains are common in the great marsh of Ambulisatra. Somewhat intermediate between the common and the Siwalik species, this rather small hippopotamus had sometimes three and sometimes two pairs of lower incisors. Certain traditions current among the Malagasy, suggest that this species may have lived within the historic period, and it may even be one of several mysterious animals alluded to by an early European voyager.

In addition to the common species, southern Europe, inclusive of Malta and some of the other Mediterranean islands, was the home of one or two smaller varieties or species, which seem to pass imperceptibly into one another until they dwindle down to the proportions of the Liberian species. Possibly these small forms may have been more or less completely terrestrial in their habits.

The three Indian species have been already sufficiently discussed, while mention has been likewise made of the Burmese hippopotamus. The latter species, by the way, was decidedly pig-like in many parts of its structure, and may well, therefore, have been a marsh-haunting animal. It was at one time thought that one of the later Indian hippopotami was an unknown animal referred to in Sanscrit literature, but further investigation has shown this view to be untenable. Eastwards of Burma, we are unaware that there is any evidence of the existence of these animals, and they appear to have been always unknown in the New World.

Although it is possible that in Madagascar Lemerle's hippopotamus may have been exterminated by human agency, such an explanation will not hold good with regard to the other fossil species. So far as we can see, India and Burma are now in every way as well fitted to be the dwelling-places of hippopotami, giraffes, and ostriches as they were during the Pliocene period, when those animals either wallowed in their lakes and rivers, or stalked over their plains; and as the former countries have not been completely swept during the interval by a glacial period, it seems impossible to divine the reason why these creatures should have so completely vanished from the one area and have survived in full strength in the other.

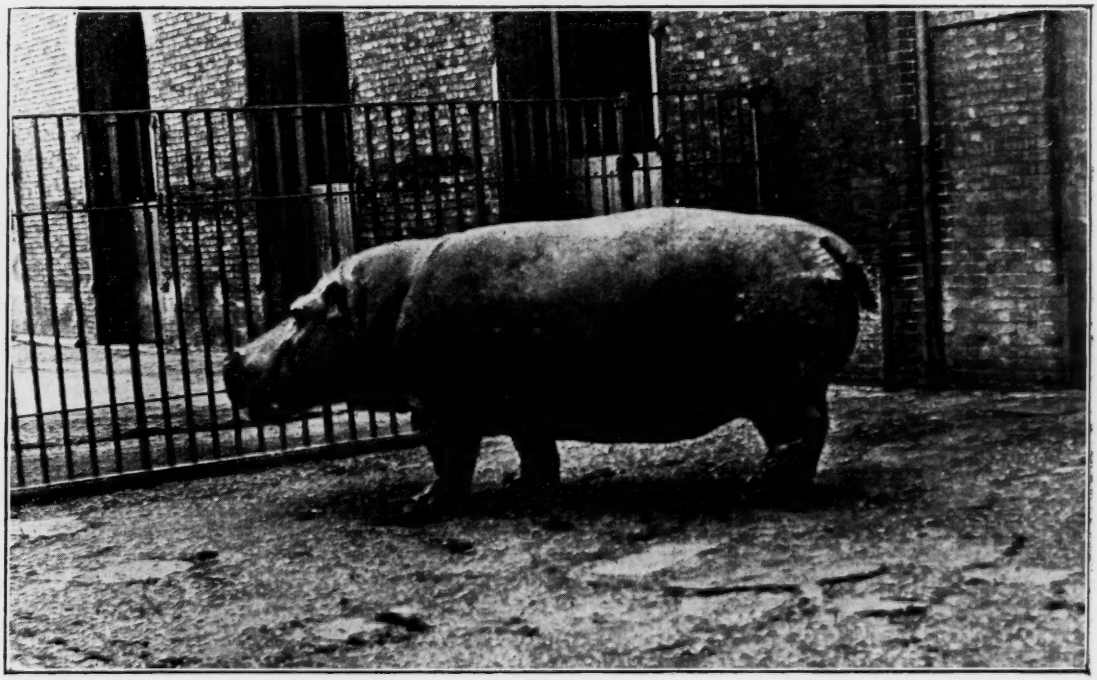

FIG. 4.—Side view of "Guy Fawkes," the large female Hippopotamus, in the Gardens of the Zoological Society. Now twenty-one years old.

NAKED EYE DOUBLE STARS DISCOVERED BY BURNHAM.

MR. BURNHAM has been especially successful in discovering two new classes of double stars—namely, naked eye stars with close companions, and naked eye stars with faint companions.

Both classes of stars form excellent, though mostly very difficult, test objects, and a list of them will, no doubt, be valued by readers of KNOWLEDGE who possess instruments of good quality. The numbers on the left hand are the numbers in Mr. Burnham's catalogues. These will enable observers to verify their observations when they have independently made their measures or estimates of the position, angle and magnitude of the companion.

CLOSE PAIRS.

β	STAR.	DIST.
1147	2 Andromedæ	0·23″
1212	24 Aquarii	0·55
172	51 Aquarii	0·68
1220	ψ^1 Aquarii (B C)	0·22
755	Argus 34	0·77
101	9 Argus	0·22
1240	26 Aurigæ	0·16
328	Canis Majoris 139	0·51
1099	B. A. C. 255	0·12
513	48 Cassiopeiæ	0·58
414	Centauri 315	1·00
1176	48 Cephei H	1·18
395	Ceti 82	0·75
1163	Ceti 199	0·19
220	Crateris 22	0·65
1129	Gr. 2829	0·34
64	1 Delphini	1·00
151	β Delphini	0·50
962	26 Draconis	0·62
744	Eridani 299	0·79
311	Eridani 315	0·98
881	46 Eridani	1·29
1241	3 Geminorum	0·53
1058	4 Geminorum	0·30
1008	η Geminorum	1·08
1192	ν Geminorum (B C)	0·15
587	15 Hydræ	0·59
341	Hydræ 348	0·66
239	59 Hydræ...	0·86
694	Lacertæ 4	0·64
1076	55 Leonis...	0·99
314	Leporis 3	0·82
766	δ^2 Microscop.	1·06
16	3 Monocerotis	1·88
241	Ophiuchi 74	0·75
1117	24 Ophiuchi	0·58
1118	η Ophiuchi	0·36
631	Ophiuchi 255...	0·36
1125	68 Ophiuchi	0·89
1032	σ Orionis	0·23
989	κ Pegasi	0·2
1144	η Pegasi (B C)	0·29
718	64 Pegasi	0·69
720	72 Pegasi	0·33
733	85 Pegasi	0·79
1170	χ Persei (B C)	0·27
524	20 Persei	0·15
1179	34 Persei	0·68
535	38 Persei	0·87
1029	ξ Persei	0·85
1164	95 Piscium	0·39″
506	η Piscium	0·99
5	103 Piscium	1·07
947	β Scorpii	1·03
120	ν Scorpii	0·80
416	Scorpii 185	0·58
391	κ Sculptoris	0·94
348	2 Serpentis	0·76
619	Serpentis 55	0·59
547	47 Tauri	0·91
1007	126 Tauri	0·2
1077	α Ursæ Majoris	0·97
932	Virginis 550	0·51
612	B. A. C. 4559	0·31

WIDE PAIRS.

1095	28 Andromedæ	2·42
999	ω Andromedæ	2·28
717	8 Andromedæ	7·43
1034	7 Aquarii	2·09
279	ω^2 Aquarii	5·86
287	ξ Aquilæ	5·63
757	Argus 101	2·57
1061	κ Argus	9·98
1063	ξ Argus	4·63
1064	19 Argus	1·84
878	66 Arietis	1·29
1046	9 Aurigæ	6·29
888	σ Aurigæ	8·60
901	65 Aurigæ	11·14
1086	47 Bootis	6·03
750	γ Cæli	2·69
1043	3 Camelopardis...	3·92
1187	5 Camelopardis...	12·89
930	B. A. C. 4389	2·67
608	17 Canes Ven.	1·22
753	λ Canis Majoris	1·29
21	η Canis Majoris	3·99
668	B. A. C. 7080	4·64
492	B. A. C. 201	2·11
497	B. A. C. 239 (B C) ...	0·76
1098	ν^1 Cassiopeiæ	12·79
1028	γ Cassiopeiæ	2·15
396	B. A. C.	1·28
1101	ψ Cassiopeiæ	2·93
1103	44 Cassiopeiæ	1·73
785	49 Cassiopeiæ	5·40
843	Centauri 219	1·70
1160	B. A. C. 230	1·19
399	Ceti 211	1·66
7	58 Ceti	2·63
1080	17 Comæ	1·79
1081	37 Comæ	5·15
1087	τ Coronæ	3·10
1245	ξ Corvi	4·81
600	Crateris 36	1·23
1131	θ Cygni	3·79
980	η Cygni	7·21
675	51 Cygni	2·99
677	T Cygni	9·91
65	13 Delphini	1·54
946	B. A. C. 5248	1·43
1090	β Draconis	4·04
11	ρ^2 Eridani	2·64
877	γ Fornacis	12·03
1193	36 Geminorum	10·81
1009	τ Geminorum	1·75

β	STAR.	DIST.
1194	65 Geminorum	13·91″
1062	82 Geminorum	4·06
771	σ^3 Gruis	2·46
1198	τ Herculis	6·70
625	ω Herculis	1·76
816	31 Herculis	5·28
818	32 Herculis	3·64
627	52 Herculis	1·62
954	54 Herculis	2·56
130	90 Herculis	1·63
590	29 Hydræ	10·95
1075	ϕ^3 Hydræ	3·03
940	52 Hydræ	4·27
105	κ Leonis	2·79
599	65 Leonis	1·78
913	50 Leonis Min.	12·27
320	β Leporis	2·89
94	Leporis 61	2·61
106	μ Libræ...	2·01
618	ι^1 Libræ (B C)	1·40
648	B. A. C. 6480	1·29
16	3 Monocerotis	1·88
17	4 Monocerotis	3·21
1124	67 Ophiuchi	6·79
290	34 Pegasi...	2·71
874	5 Persei...	5·40
875	9 Persei...	11·64
276	η Piscis Australis	1·61
772	δ Piscis Australis	4·78
286	8 Sagittarii	6·03
760	η Sagittarii	3·51
1033	ν^2 Sagittarii	1·37
654	52 Sagittarii	3·00
763	κ^2 Sagittarii	1·33
36	2 Scorpii	2·86
39	11 Scorpii	3·25
1013	δ Sculptoris	3·34
32	6 Serpentis	2·44
1031	Aldebaran (C D)	1·83
1045	99 Tauri	6·21
1067	o Ursæ Majoris	7·01
1071	θ Ursæ Majoris	5·15
1082	78 Ursæ Majoris	1·46
924	31 Virginis	3·94
248	2 Vulpeculæ	1·92
1130	9 Vulpeculæ	9·53

THE LUMINIFEROUS ETHER.

By J. J. Stewart, B.A.Cantab., B.Sc.Lond.

IN the earlier theories of electricity and magnetism, "action at a distance" was considered a sufficient explanation of the mutual influence of electrified bodies or magnets upon each other. Bodies charged with electricity were stated to attract or repel each other with a force varying inversely as the square of the distance, and no account was given or inquiry made as to the mechanism whereby these attractions and repulsions were excited, though actions of material systems on each other at a distance without any intervening medium seems an unthinkable hypothesis.

To Faraday is due the fruitful theory that these electrical actions are caused by stresses and strains in a medium surrounding and interpenetrating the electrified bodies, and he mapped out the surrounding space by a set of curving lines of force. He showed that the actual phenomena may be explained by supposing a tension along the lines of force, combined with a pressure at right angles to them. This theory has been further developed by Clerk Maxwell, who showed that it gave a consistent explanation of the behaviour of electrified bodies and of magnets.

But the existence of some medium filling interplanetary space is demanded by the undulatory theory of light, in order to account for the transmission of light-waves from the heavenly bodies, and from all luminous objects to our eyes. Many facts go to prove that the dark radiations, which do not affect our sense of sight but which produce heat in the matter on which they fall, are conveyed by the same medium, and that the heat-producing waves differ only from the luminous vibrations in having a greater wave-length; the two radiations therefore seem to be essentially the same, but when the waves are shorter and more rapid than the luminous ones, they do not affect our nerves of sight, though their chemical effects may be observed and their existence made manifest by their photographic action.

The existence of a medium capable of conveying radiation by some sort of periodic vibration being abundantly confirmed by the various phenomena of light, the question arises whether it is not the very same medium whose stresses and strains may account for the observed electric effects. It would simplify matters much if we had not to suppose separate ethers to account for the various phenomena in the different departments of physical research. These various effects are considered by us separately and placed in different categories because they manifest themselves to us in differing ways, but they may all be due to different forms of energy exerting influence through the same medium. To reduce the explanation of physical phenomena to as few forces as possible is simpler and more satisfying to the mind, and the tendency of physical research and modern speculation is to form wider and more comprehensive generalizations, which enable us to include various and apparently disconnected phenomena under the same far-reaching laws. For the departments of electricity and light this has been to a great extent done by the famous electro-magnetic theory of Clerk Maxwell, which considers light as an electro-magnetic phenomenon, and explains the vibrations of light as consisting of some sort of alternate electric polarizations of the particles of the luminiferous ether.

Let us consider a little what is known of this all-pervading medium, through which are manifested all the remarkable effects of electricity and light and radiation.

Maxwell's theory has recently received a striking confirmation and illustration by the brilliant experiments of Dr. Hertz, who has investigated the behaviour of long electro-magnetic waves and has not only found that they are capable of reflection, refraction and polarization, but measured their wave-length. He finds that their behaviour is quite analogous to the behaviour of light-waves, and that they differ merely in having a greater length.

It is possible that the attraction of gravitation may also be due to stresses in the ether, though the cause of gravitation no one has yet been able to explain. It is highly probable that if we were acquainted with all the properties of the luminiferous ether, the knowledge would include an explanation of the mechanism of gravitation.

Newton emphatically rejected the idea of action at a distance. He says in his *Letters to Bentley*: "You sometimes speak of gravity as essential and inherent to matter. Pray do not ascribe that notion to me; for the cause of gravity is what I do not pretend to know, and therefore would take more time to consider of it. It is inconceivable

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that inanimate brute matter should, without the mediation of something else which is not material, operate on and affect other matter without mutual contact, as it must do if gravitation, in the sense of Epicurus, be essential and inherent in it. . . . . That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a *vacuum*, without the mediation of anything else by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws, but whether this agent be material or immaterial I have left to the consideration of my readers."

Newton explained the phenomena of light as due to luminous corpuscles emitted with great velocity from shining bodies. He rejected the undulatory theory because he could not explain by it the propagation of light in straight lines, but some of his ideas closely resemble and agree with those of the theory of undulations; and he also supposed the existence of an all-pervading ether, and used the undulatory theory to account for the occurrence of reflection and refraction.

He imagined that his luminous corpuscles on striking surfaces produced waves in the ether, and by the action of these waves alternate fits of easy reflection and easy transmission were communicated to the luminous particles, so that sometimes they were in a state to be reflected and sometimes in a condition to be refracted at a transparent surface. He applies his observations on the colours of thin plates to this hypothesis, and develops it with extraordinary ingenuity. Many of his notions as to the waves produced in the ether agree far more closely with the undulatory theory than has been generally supposed. He compares the waves in the ether to those produced on throwing a stone into water. He says: "What kind of action or disposition this is—whether it consists in a circulating or a vibrating motion of the ray, or of the medium, or something else—I do not here inquire." He considered that vibrations or tremors were excited in the reflecting or refracting medium at the point of incidence, that they were propagated to great distances, and that they overtook the rays of light and successively put them into the fits of easy reflection and easy transmission. In the queries at the end of his *Opticks*, he asks: "Is not the heat of the warm room conveyed through the *vacuum* by the vibrations of a much subtler medium than air? And is not this medium the same with that medium by which light is refracted and reflected, and by whose vibrations light communicates heat to bodies, and is put into fits of easy reflection and easy transmission?" He gave as a possible explanation for gravitation that the ether was much rarer within the dense bodies of the sun, stars, and planets than in the spaces between them; that it grew denser and denser as the distance from these bodies increased, and thereby caused the gravitation of the bodies towards each other, every body tending to go from the denser parts of the medium towards the rarer. Again he asks: "Is not vision performed chiefly by the vibrations of this medium excited in the bottom of the eye by the rays of light, and propagated through the solid, pellucid, and uniform capillamenta of the optic nerves into the place of sensation?"

The ether must be of extreme tenuity and imponderable. Its presence cannot be detected by our senses, and its properties must be discovered by a process of reasoning founded on its behaviour, as manifested, for example, in the transmission of luminous vibrations. Its properties are to a great extent at present unknown. We know that it must fill the celestial spaces as far as the most distant stars; and from the propagation of light through transparent material we judge that the ether must evidently interpenetrate solids and fluids, for the matter of the solid body itself is incapable of transmitting vibrations with the enormous rapidity of those of light. From phenomena such as the polarization of light it is seen that the direction of the vibrations must be transverse to the direction of propagation.

As fluids cannot give rise to transverse vibrations, the ether was supposed to behave like an elastic solid, or at any rate to possess some property analogous to rigidity or resistance to change of shape. As a first step, the vibrations constituting light were regarded as actual periodic displacements of the particles of the ether in the wave front, and transverse to the direction in which the wave is moving. A solid gives rise to longitudinal vibrations as well as to transverse ones, and to get rid of the complication arising from the existence of the former the ether was supposed incompressible; then the velocity of propagation of the longitudinal disturbance would be infinite. Sir G. Stokes has pointed out that though the ether may act as a perfect fluid for large and comparatively slow displacements, those occurring in the propagation of light may be so small and so rapid that for them the ether behaves like an elastic solid.

The ether must be supposed to freely pervade all material bodies. As all bodies are compressible, their constituent molecules cannot be in contact, and the ether may be regarded as surrounding and bathing them, the molecules floating as it were in an ocean of ether. But the ether is affected by the presence of the molecules of matter, and this is shown by the bending or refraction of rays of light when they enter transparent substances. This refraction is accounted for in the undulatory theory by the difference of the velocity of the light-waves through a vacuum and through ponderable matter. The presence of the particles of matter causes the speed of transmission of light to be less. At first sight it appears difficult to believe that a dense solid substance like glass should have its molecules so far apart as to allow of a free penetration of the ether amongst them, and that this contained ether should also be free to vibrate and thus transmit the periodic disturbances producing light. But we know that a magnet can act through a plate of glass and attract a mass of iron on the other side, and this magnetic influence must be conveyed through some medium from the magnet to the iron. Neither the magnetic influence nor the ethereal medium is directly observable by our senses, but the existence of both is inferred by our intellect from the effects produced.

From the fact that ether is capable of transmitting with a finite velocity the vibrations which convey light, it would seem to follow that it must be endowed with inertia, or some property answering to mass in ordinary matter. As these vibrations are transverse, it must also possess a quasi-rigidity or an elasticity analogous to that by which a solid body resists a force tending to change its shape, or opposes the gliding of its particles over one another. It may be continuous; at any rate, if it has a molecular structure it must be different from that of gases, which cannot transmit transverse vibrations. If it be supposed to consist of molecules at a distance from each other, the same difficulty as to action at a distance between these separated particles would occur, for action at a distance across empty space is not more easy to understand when the distance is extremely small than it is when the distances are those we have to deal with in astronomy.

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BROOKS' COMET. Enlarged from a Photograph by Prof. E. E. Barnard,

Taken October 21st, 1893; exposure 16h. 37m. to 17h. 12m., Standard Pacific Time. The arrow from the nucleus shows the direction of motion of the Comet, and the distance passed over in the succeeding twenty-four hours.

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WHAT IS A COMET'S TAIL?

By A. C. RANYARD.

NO bride was ever covered by such a transparent gauzy veil as that which trails behind a comet as it comes to do obeisance to the sun, or as it backs like a courtier out of the solar presence, keeping its train behind it. It has frequently been noticed that the light of small stars is not sensibly dimmed when the tail of a large comet sweeps between the earth and the star; therefore, to compare the matter of comets' tails with a white mist, or a silver fog in space, is too gross a comparison. A few hundred yards of the thinnest fog or mist we are familiar with, cuts down very materially the light of objects seen through it, but the light of a star in passing through the tail of a large comet must have travelled through hundreds of thousands of miles of the nebulous material which is streaming away from the nucleus. The thickness of light-absorbing material traversed by a ray of light makes a greater difference than would at first sight be suspected in the amount of light transmitted through a fog or haze, or other absorbing medium, for the light lost increases in geometrical proportion as the thickness of the light-absorbing medium increases in arithmetical proportion; thus, if a haze ten miles thick reduced the light of an object seen through it by one half, a similar haze twenty miles thick would absorb three-quarters of the light that would otherwise be transmitted, for the second ten miles of haze will halve the light that has been transmitted through the first ten miles. Thirty miles of such haze will reduce the light to an eighth, and two hundred miles of such haze will reduce it to about one millionth, for two to the power of twenty is a little more than a million.

On the clearest summer day the brightness of objects at a distance of ten miles on the horizon is reduced to less than one half by the absorption of the intervening atmosphere—a fact that becomes very evident to photographers who attempt to photograph distant objects, and who find that long exposures are necessary to obtain upon their plates any trace of the blue distance which so charms the eye. The tail of a comet must consequently be far more transparent than the earth's atmosphere; indeed, a mass of gas as bulky as the tail of a large comet would—even if it were a thousand times more transparent than air—act as an opaque screen in space, cutting out the light of the stars, and probably even eclipsing the light of the sun itself, if such a cometary tail should pass between the earth and the solar disc.

The light derived from the tail of a comet is generally found to give a bright line spectrum in the neighbourhood of the nucleus, and to be more or less polarized at a greater distance from the nucleus. The bright lines seem to point to the presence of incandescent gas, and have frequently been taken to indicate a high temperature in the region about the nucleus; but the spectrum of the aurora which glows in the cold upper strata of our atmosphere is also characterized by narrow gaseous lines, and many comets begin to glow and throw out tails in regions of the solar system where they can derive but little heat from the warming effect of the sun's rays.

Thus, according to Mr. Marth, comet Brooks, at the time of the photograph reproduced in our plate (October 21st), was at a distance 1·02 times the earth's mean distance from the sun—that is, it was at a little greater distance from the sun than the earth ever is.* We may therefore compare the temperature of the comet as derived from the sun's rays, at the time that its photograph was taken by Prof. Barnard, with the temperature of the moon, and it was shown in the article in the April number that the temperature of the moon's equatorial regions during the lunar day probably does not exceed the temperature of melting ice. Consequently, if the ebullition which was evidently going on in the nucleus of Brooks' comet at the time the photograph was taken was due to the rapid driving into vapour of matter by the sun's heat, the material that was being vaporized must have had a very low melting point, such as is possessed by carbonic acid or substances which freeze at a still lower temperature, such as hydrogen, nitrogen, and other forms of matter which in terrestrial laboratories we are, under ordinary circumstances, only familiar with in their gaseous state.

The way in which comets' tails, as a general rule, slowly develop in size as they approach the sun, and again diminish as they recede from him, would seem to point to the conclusion that the growth of comets' tails is principally due to the intensity of the sun's heat, or to some other cause which varies with the distance of the comet from the sun. But the rapid variations in form and brightness which many comets have exhibited seem to show that the evolution of gas from the nucleus, and the repulsion of matter in the tail, is influenced or in some way partly controlled by some more irregularly varying conditions, such as collisions with meteors, or dust in space, or the passage of the cometary nucleus through a mass of gas. The rapid variations in form and brightness which a comet sometimes undergoes are well illustrated by the four photographs of Swift's comet, taken by Dr. Max Wolf, which are reproduced in our second plate. A still more striking instance of a rapid increase of brightness was afforded by Holmes' comet, which, at more than double the earth's distance from the sun, seems to have suddenly brightened up.

Before attempting to speculate on the causes of these irregular variations in brightness, it may be well to give an account of the phenomena which are usually observable. A comet when it is first seen as it approaches the sun, and also when last seen as it recedes from the sun, generally appears as a small roundish patch of faintly luminous nebulosity, sometimes with a brighter patch or stellar point near the centre. As the comet brightens on approaching the sun it generally begins to emit jets or streamers, or to form more or less symmetrical envelopes on the side next the sun, and develops a tail on the side remote from the sun. In the great comet of 1858, usually known as Donati's comet, the action was most symmetrical, one envelope after another rising from the nucleus and expanding, as if the material forming the envelopes was repelled by the nucleus, and was also repelled by the sun, till it was ultimately driven away within a hyperbolic envelope or stratum which formed about the nucleus.

The tail in this and other comets seemed to be composed of hollow cones slightly bent backwards in the plane of the orbit. The backward curvature is easily explained, because particles repelled from the comet's head would still retain their original orbital motion, and would fall behind the line drawn from the sun through the comet's nucleus, as they were driven into a larger and larger orbit. The amount of backward curvature of the tail evidently depends on the velocity with which the particles are driven away from the sun, and we find in this and other comets multiple tails, indicating that the different branches of the tail are composed of different materials which are repelled from the sun with different velocities.

But in Dr. Max Wolf's photographs of Swift's comet we

* During our summer in the Northern Hemisphere the earth attains a distance of 1·01677 times its mean distance from the sun.

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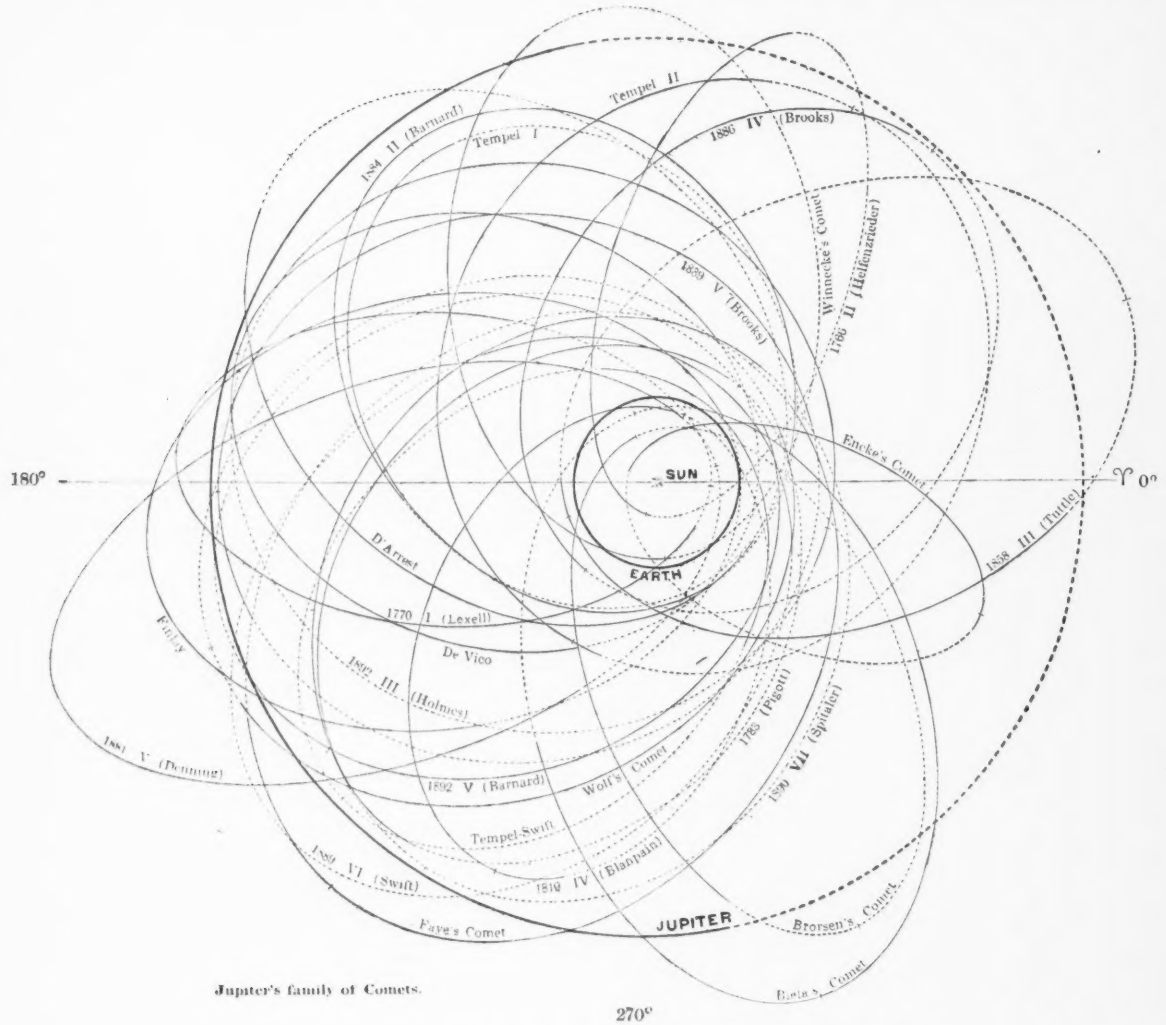
find no such hyperbolic strata enveloping the nucleus; the matter seems to be driven directly away from the nucleus, and not in the first instance to be driven into an envelope about the nucleus prior to its being driven away from the sun. Perhaps the discrepancy may be explained by the repulsion from the nucleus being comparatively feeble, so that the envelopes about the nucleus are small and are hidden by the nebulosity about the head of the comet. In Swift's comet, the streams of matter radiating from the nucleus all seem to be bounded by straight lines, though they radiate in slightly different directions from the nucleus. In the photograph of Brooks' comet there are similar straight rays radiating from the nucleus in addition to the curious curved and branching structure which forms the brightest part of the tail. If we look for an analogy with the more regular structures of Donati's comet, it would seem that the great branching structure corresponds to one of the jets which issued from the head of Donati's comet, while the small straight rays in Brooks' comet correspond to the streams which formed the bulk of the tail in Donati's comet.

The plate of Brooks' comet has been produced from a dense collodion enlargement, made from a glass positive sent over by Prof. Barnard. It is entirely untouched, and shows the great variations of brightness in different parts of the tail. The spectral lines observed in the light from the heads of different comets indicate that the chemical constitution of one comet differs from another, and it is perhaps to be expected that the general appearance of comets, and the phenomena they exhibit, should also vary according to the materials of which they are composed.

The light from the remoter parts of the tail is usually more or less completely polarized according to the position of the comet with respect to the sun and earth, in a manner which indicates that the matter of the comet's tail disperses the sun's light as fine dust would do. It seems, therefore, probable that the remoter parts of the tail of a comet consist of very minute particles, whose average diameter is small compared with the wave-length of light, and that the material of which it is composed has been precipitated from the gaseous matter driven off from the nucleus.

In 1872 the medal of the Astronomical Society was given to Prof. Schiaparelli, of Milan, for showing that there was an intimate connection between certain meteor



Jupiter's family of Comets.

The dotted portions represent the parts of the orbits below, *i.e.*, to the south of the ecliptic.

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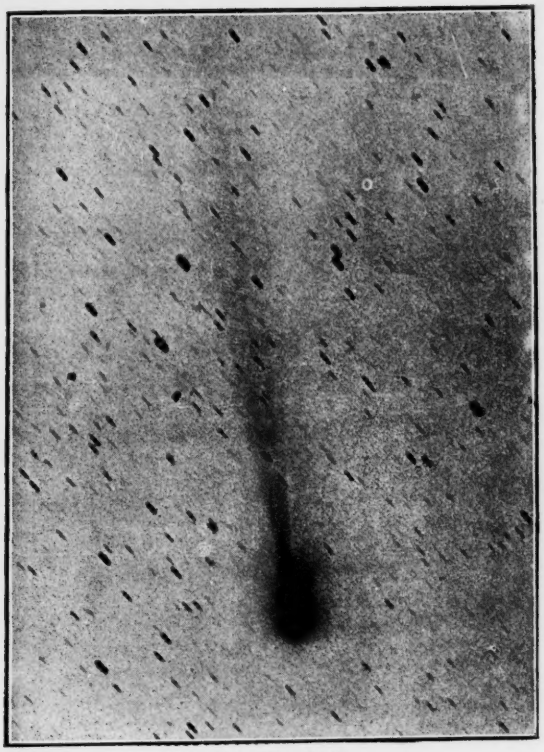

FIG. 1. 26th May, 1892.

FIG. 2. 27th May, 1892.

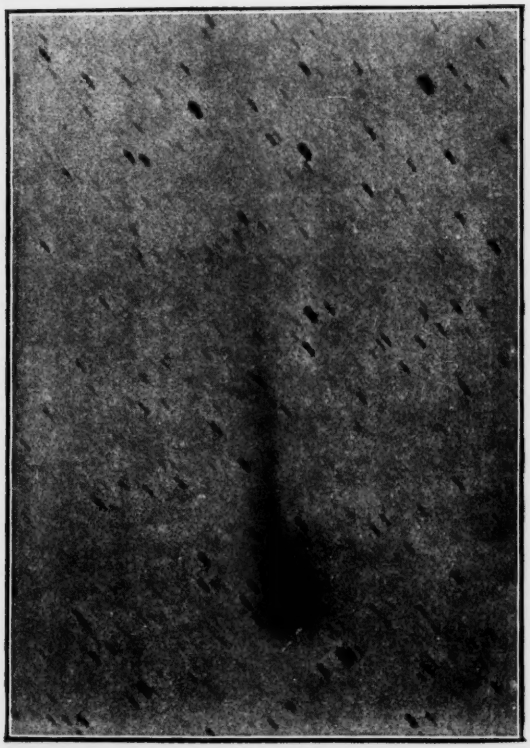

FIG. 3. 28th May, 1892.

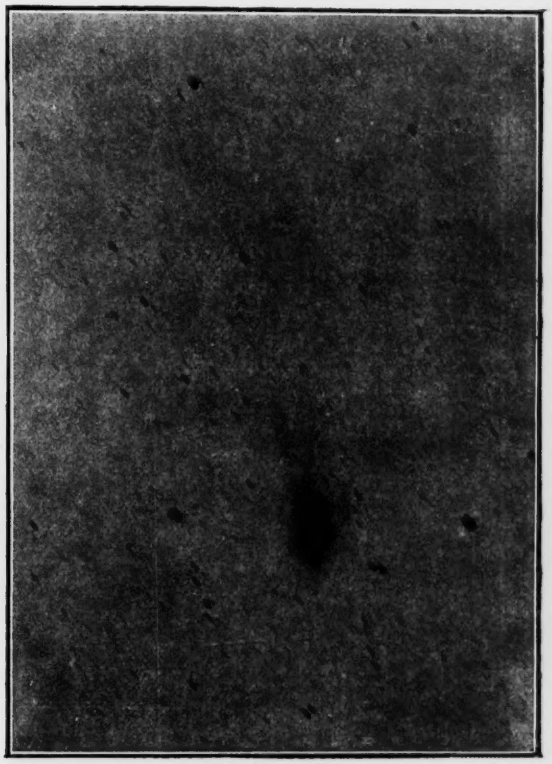

FIG. 4. 2nd June, 1892.

PHOTOGRAPHS OF SWIFT'S COMET.

Taken by Dr. MAX WOLF, of Heidelberg, showing the rapid changes taking place.

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streams and comets. He showed that the August meteors revolve in an orbit which is, as near as can be determined, identical with the orbit of Comet II. 1862, usually known as Tuttle's comet, and that the November meteors move in an orbit which is practically identical with the orbit of Comet I. 1866, known as Tempel's comet. A few years later it was shown that the Andromid meteors are revolving in a track which is practically identical with the orbit of Biela's comet, and that the April meteors are also associated with a cometary orbit. In view of this evidence, it seems highly probable that the nebulous matter which renders comets visible is evaporated from meteor swarms as they approach the sun, and that the matter thus separated from the meteors is repelled by the sun, never to be regathered by the meteor swarm. It would follow that the meteor swarms which are associated with comets are wasting away and losing a portion of their substance every time that they approach the sun. Possibly some of the particles driven away may fall upon the planets and go to augment their atmospheres, taking the place of carbon, oxygen, and other elements which have been absorbed or added to the solid substance of the planet by the processes of life, oxidation, and other chemical changes continually going on; and it would seem to follow that comet-producing meteor swarms cannot last for geologic ages, and that those which are now associated with comets must have been introduced into the solar system within a comparatively recent period—a conclusion which is opposed to Mr. Proctor's and Sir Robert Ball's ejection theory, which assumes that comets and meteors had their origin within the solar system, and were ejected from the sun and the larger planets at an early period when these bodies were in a sun-like state.

The accompanying diagram (page 114) has been copied from a drawing made by Mr. A. G. Sivaslian, of Northfield, Minnesota. It represents Jupiter's family of comets, and was originally published in an interesting article by Prof. W. W. Payne in the October number of his "Popular Astronomy."

It will be noticed that nearly all the farthest points of these orbits (the aphelia) are on one side of Jupiter's orbit, and that the places where the dotted portions of the orbits join the continuous ones are in nearly every case close to the orbit of Jupiter. The dotted portions of the orbits are below the ecliptic, while the continuous portions are to the north, so that one of the nodes of the comet's orbit is in every case near to the orbit of Jupiter. If Jupiter were at that part of his orbit at the time when the comet was passing its node, the two bodies would really be near to each other, and Jupiter by his great mass would have a very marked influence in changing the orbit of the comet. It seems, therefore, probable that all these comets have at some time been considerably perturbed by Jupiter.

The sun and the whole solar system is moving through space towards a point in the constellation Hercules, having a right ascension of about 269° and a north declination of about 35°. The bottom of the plate corresponds to right ascension 270°; consequently, a vertical line on the page approximately corresponds to the direction in which the solar system is moving—probably at a rate of some ten miles a second.* Jupiter is moving in his orbit with a mean velocity of a little more than eight miles a second, in a direction contrary to the hands of a watch when looked at from above the ecliptic, as in the diagram; consequently, when Jupiter is in the part of his orbit which lies on the left hand side of the diagram he is moving very rapidly through space, with a maximum velocity of about eighteen miles a second, while in the part of his orbit which corresponds to the right hand side of the page he is moving in a direction about the sun nearly contrary to the sun's motion in space, and when going slowest he is only moving through space with a velocity of about two miles a second. The distribution of the aphelia of the cometary orbits shows that Jupiter has caught many more comets when moving rapidly through space than when he is moving slowly. But this is only what might be expected if the comets were all originally caught from outside the solar system, and it forms an interesting additional piece of evidence tending to prove that the sun is actually moving in space, and that the comets of Jupiter's family were not originally members of the solar system.

A similar piece of evidence tends to show that the meteors we encounter were not originally members of the solar system. It has long been known that the earth encounters a larger average number of meteors in the autumn half of the year than in the spring half, from midwinter to midsummer; that is, when the earth is moving most rapidly through space it encounters fewest meteors. Exactly the contrary of this would be the case if the majority of meteors were sporadic—that is, if they came from outside space. But with meteor streams captured by the larger planets in the way in which Jupiter has annexed his comet family, we should expect to find the earth most involved amongst the perihelia of such elliptic streams on the opposite side of its orbit from that on which the larger planets are most successful in capturing such streams. The observed facts can therefore be best explained by supposing that the majority of meteors are now moving in closed orbits, which are arranged in a manner that shows that meteors as well as comets were originally captured from outside space.

* This is the velocity determined by Prof. Vogel from his observations of the motion of stars in the line of sight. It seems to be the most trustworthy determination of the velocity of the sun's motion in space that we at present have.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

MOONLIGHT PHOTOGRAPHS.

To the Editor of KNOWLEDGE.

DEAR SIR,—It seemed to me that the best way to test your theory as to the markings on Mr. Levingston's photograph, published in KNOWLEDGE for December, 1893, would be to repeat the process as an experiment. I therefore recently took the opportunity of a bright moon to expose a plate to a landscape for one hour, and then to point the camera directly to the moon; the result shows a tracing made by the moon.

The camera had a focal length of four and a half inches, with an aperture in stop of 0·4 of an inch.

I forward the plate for you to make use of as you like.

Yours truly,

Cranleigh, Surrey. J. P. MACLEAR.

[Admiral Maclear's photograph shows a band or knotted trace which is very similar in appearance to Mr. Levingston's supposed lightning flash.—A. C. RANYARD.]

METEORS IN THE LUNAR ATMOSPHERE.

To the Editor of KNOWLEDGE.

SIR,—In your interesting article on the moon, in the April number of KNOWLEDGE, you infer that it is probable the moon has an atmosphere comparable in density with

that which surrounds the earth at a height of somewhere about fifty miles above sea level, and that it is sufficiently dense to vaporize meteoric showers. If this is so, should we not see occasionally, either during observations made with the telescope, or on photographs, some slight streaks of light caused by a mass of meteorites, or a large aerolite, passing obliquely across the dark portions of the moon's surface?

Lewisham, S.E., April 15th, 1894. Yours truly, A. E. Whitehouse.

[In the earth's atmosphere we only occasionally see meteors which appear, as seen from a distance of one hundred miles, many times brighter than a star of the first magnitude. As seen from a distance of one thousand miles, such a meteor would only appear one hundredth part as bright as when seen from a distance of one hundred miles; and when seen from the distance of the moon, the apparent brightness of such a meteor would be reduced to less than one five hundred millionth part of its brightness as seen from a distance of one hundred miles, so that probably the brightest meteors in the lunar atmosphere would escape attention, as seen from the earth.—A. C. Ranyard.]

To the Editor of Knowledge.

Donville (Manche), France.

Dear Sir,—Some doubts have recently been expressed about the visibility of the whole ball of Venus, especially when it has been observed during the daytime near to inferior conjunction.

I do not wish to state that the phenomenon is a real one, but I would offer an observation which tends to show that it is not an optical illusion. I was observing Venus on January 24th, 1894, at 1h. p.m., and noticed that the entire ball of the planet was vaguely seen, of an indefinable colour, but it was impossible for me to ascertain if it was brighter or darker than the surrounding sky. It was of a kind of reddish-grey, and was much more visible with the strong eye-pieces than with the weak (the eye-piece principally employed magnified about two hundred and forty times); that is to say, as the light of the sky grew darker, by employing strong magnifying glasses, the ball of the planet and its slightly different colour from the sky became more marked. Would not an optical illusion, on the contrary, be more visible with a weak eye-piece—that is to say, one giving a brilliant image?

I am, dear Sir, yours truly,

L. Rudaux,

Membre de la Société Astronomique de France.

[The higher magnifying power would, of course, decrease the light derived from the body of the planet just in the same proportion as it decreased the light derived from the surrounding sky; but the contrast may appear more evident when the brightness of both areas is decreased. I feel no serious difficulty in assuming that the body of Venus may shine, when it is not illuminated by the sun, with a light which is comparable in brightness with the light derived from the dust in the earth's atmosphere, when illuminated by the sun's rays. This dust forms a semi-transparent veil, sufficient to hide the planets when looked for with the naked eye, but not sufficient to hide them in the telescope.

On the 24th of January, about one-seventh of the disc of Venus was illuminated by the sun. A curious fact is that the phenomenon observed by M. Rudaux seems to become more and more apparent as the planet approaches the sun, and is seen through the brighter parts of the atmospheric veil, for the general brightness of the sky increases rapidly as we approach the sun.

I have on more than one occasion, when Venus has been nearer to the sun than it was on the 24th of January, seen what appeared to me to be the whole body of the planet, clearly distinguishable on the background of sky. It may be that the light from the illuminated crescent of Venus lights up the dust in our atmosphere in the immediate neighbourhood of the planet's place, so as to render it more opaque than it is rendered by the less direct illumination of the sun's rays. The patch of illuminated atmosphere round the brighter stars is well known to all telescopic observers. With a large instrument, the brightened appearance of the sky before a large star enters the field of the telescope has been frequently compared to the light of approaching dawn. —A. C. Ranyard.]

THE AURORA AND ZODIACAL LIGHT.

To the Editor of Knowledge.

Dear Sir,—The zodiacal light has been a prominent object every clear evening of the first three months or so of each year I have spent here—nearly twenty of them. December 17th is, I think, the earliest date I have seen it, and I do not remember it later than the middle of April, with very varying extension. For the first time, yesterday I saw it in daylight, *i.e.*, immediately after sunset, of a pretty rose-colour, somewhat like the wondrous after-glows of ten years ago, but distinct in this respect, that those generally had the sun's place for centre, whereas this had not, but was an oblong, rounded mass, with its major axis lying along the ecliptic.

About 9.30 I found an aurora pervading the northern sky, chiefly in the true (not magnetic) north; low down pale green, then a bank of cloud, and above that, to within ten degrees of Polaris, rose-colour, with shootings of pencilled rays, and the complementary colours thus evenly distributed above and below the nimbus. These colours lasted only a short time, but all night I suppose (at least till 2 a.m.) the whole lower northern sky was brilliant with yellow radiance, like a summer dawn or early night, but its centre was the magnetic north. Its beauty was much enhanced by masses of cloud (looking black like nimbus, though probably they were only cumulus).

The zodiacal light is usually supposed to belong to the sun, the aurora borealis to the earth; yet last evening's displays seemed to point to a real connection or sympathy, such as is also pointed to by the connection between solar disturbance and magnetic storms. May not the sun's corona extend in an *invisible*, attenuated condition beyond our own orbit, so that we are always within it, but when the sun is more than usually active we see it at our poles as well as along the ecliptic? Would not this explain what now seems inexplicable, viz., the immediate magnetic sympathy between the earth and the sun?

I once asked Mr. Proctor to give us a monograph on the zodiacal light, putting together all the known facts and probable theories. I wish that I could induce you to take the matter up. Yours faithfully,

A. P. Skene.

Pornic, Loire Inf., France, March 31st, 1894.

[I am collecting facts with regard to auroral displays, which I hope to put together for publication. I have recently had an opportunity of examining some very interesting photographs of the aurora, taken during the past year by Dr. Martin Brendel. I may, perhaps, be allowed to reproduce them in Knowledge. Mr. Skene will find a short paper "On the Connection between Sunspots and Magnetic Storms" in Knowledge for April, 1892. I still hold to the theory there advocated. It assumes that

magnetic storms, as well as auroral displays, are caused by the passage of the earth through a dust-laden region or stream of matter projected from the sun beyond the region ordinarily occupied by the coronal streamers.—A. C. RANYARD.]

THE FORMATION OF DIAMONDS.

To the Editor of KNOWLEDGE.

DEAR SIR,—The following remarks of Dr. Joly, of Dublin, who has been engaged in measuring the rate at which diamonds expand on being heated, may interest your readers. Commenting upon the fact that the co-efficient of expansion increases very rapidly at about 750° C., Dr. Joly remarks, in a recent communication to *Nature*, that "the sudden increase in volume at high temperatures suggests that the diamond is a form of carbon which has been subjected to high pressure when crystallizing. Such changes we may expect to be reversible, and it is supposable that equilibrium at the higher density is only preserved by crystalline forces which will require to be brought into play by external conditions of pressure. It is probable that this is therefore an essential condition of success in its artificial production. It is perhaps of interest, adds Dr. Joly, that this reasoning gave rise to experiments—as I had leisure for them—which I only laid aside finally upon hearing of M. Moissan's success. I did not seek the aid of solution in a metal, but used an apparatus to compress graphite, as well as carbon prepared from sugar, between iron plates kept at a red heat and urged together by the alternate heating and cooling of the bars of an iron yoke. I am not without hope," says Dr. Joly, "that the use of high pressure at a high temperature may ultimately prove sufficient, without resort to solution in a metal, to produce diamond." Yours faithfully,

VAUGHAN CORNISH.

BROOKS' COMET.

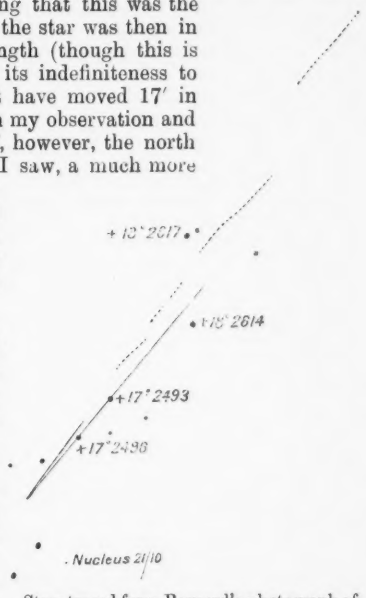
To the Editor of KNOWLEDGE.

SIR,—Has anyone tried to make out the correspondence between the details of the two photographs of Brooks' comet in the February number of KNOWLEDGE? They are so very different that it is not easy to see the connection between them. It is a pity if no photographs were obtained in the intervening twenty-four hours, as with such a rapidly changing object as this comet was, more frequent photographs are very desirable.

I made an eye observation in the interval, but scarcely any of the detail shown in the photographs was visible to me. The difference between the amount that could be seen and that photographed is indicated by the fact that I traced the tail to a distance of just 2°, whereas in the photographs the total length is 3·7° on the 21st, and on the 22nd, including the detached portion, 4·4°.

It may be well to give my description at that time, viz., Oct. 22nd, 16h. 40m., G.M.T.: "With power 20 on a 4¼in. refractor, at first sight the tail seems strongly curved (concave to preceding side), but on closer examination this is found to be caused by the following part being brightest to some distance from the nucleus, viz., to near the star B.D. + 17°, 2496, when it fades rapidly, and a portion further preceding brightens—B.D. + 17°, 2493 being at the brightest part—this part seeming to be straight, and continuing to be the axis to the end. The central line of this part of the comet is at B.D. + 17°, 2496, or perhaps slightly preceding it, and passes B.D. + 17°, 2493 and ⅔ from B.D. + 18°, 2614 to B.D. + 18°, 2617, going a little beyond. The brightening of the tail about B.D. + 17°, 2493 is an unusual feature, reminding me of the photographs of comet I. 1892 in KNOWLEDGE, &c. With field glasses, power 4, the comet is faintly visible, and the tail strongly curved, the details above described not being discernible. The tail, however, is visible to the same distance as with power 20."

There can be no doubt that the bright patch I saw about B.D. + 17°, 2493, although very indefinite, must have been a similar one to the two striking ones shown in the photograph on Oct. 22nd, though it is singular I saw but one instead of two. At the time of my observation, allowing for the motion of the nucleus in the interval, the star B.D. + 17°, 2493 would be in the axis of the south one in the photograph, about ⅛ from its south to its north extremity. Assuming that this was the one I saw, and that the star was then in the middle of its length (though this is uncertain owing to its indefiniteness to me) the patch must have moved 17′ in the 8¼ hours between my observation and the photograph. If, however, the north patch was the one I saw, a much more rapid motion is indicated; but this seems improbable, that patch not being in the same line from the nucleus.



Stars traced from Barnard's photograph of 21st October, 1893. ——— Axis according to T. W. Backhouse, 22nd October, 16h. 40m. G.M.T. ..... Axis of bright patch.

Fitting my drawing to the scale of the photograph, the bright ray emanating from the nucleus and forming the main part of the tail for a long distance fits accurately, as far as it goes, on to the same in the photograph; but it had evidently grown considerably in the 8¼ hours' interval, for it is brilliant in the photograph to a distance of 0·83° from the apex of the head, while I could not trace it at all more than 0·53° from the nucleus, thus indicating a growth of at least 18′ in the interval. But it is singular that the preceding side of the tail, joining the bright patch to the nucleus, is scarcely perceptible in the photograph, while it was quite plain to me.

Allowing for the motion of the nucleus, it is remarkable that the further part of the axis of the tail, as seen by me, lies from 2′ to 3′ preceding the preceding edge of the tail in the photograph on the 22nd, excepting that there appears to be therein a very faint ray further preceding, in continuation of the preceding edge of the south bright patch.

Yours truly,

T. W. BACKHOUSE.

West Hendon House, Sunderland.
April 6th, 1894.

METHOD BY WHICH A PATIENT MAY OBSERVE A CATARACT IN HIS OWN EYE.

To the Editor of KNOWLEDGE.

DEAR SIR,—I see from newspaper reports that the eyes of Signor Crispi, Prime Minister of Italy, are in the same condition as those of Mr. Gladstone, and that the eyes of

Sir William Vernon Harcourt are nearly as bad. The Czar's favourite Minister of Finance is also said to be in the same plight. With such a visitation of cataract in the eyes of public men, your readers may possibly be interested in the following account of a simple method I have discovered which enables a patient to see a cataract in his own eye and note its growth and development, probably better than any oculist can observe it for him.

Cataract is said to be due to the gradual deposition of oxalate of lime in the substance of the crystalline lens, at first in small spots or streaks, sometimes in one part and sometimes in another. The deposit gradually increases until it penetrates the whole of the lens, causing blindness. The remedy, then, is to remove the lens, and after its removal the patient needs a substitute in the form of highly magnifying spectacles.

All that is necessary to enable a patient to see his own cataract for himself is a piece of card and a needle—a visiting card will do very well. Pierce a clean round hole near the middle of the card and hold the card up to the light close to the eye, looking preferably in the direction of a piece of blue sky. With the card near to the eye, the patient will not see the small hole pierced by the needle, but he will see a comparatively large faintly illuminated field with his cataract projected upon it. He is, in fact, observing the shadow cast by his cataract on the retina at the back of his eye. With a small puncture in the card the shadow so thrown is comparatively sharp. But with a normal eye an evenly illuminated field or clean disc will be seen. The patient may thus map down his own cataract, and settle for himself whether it is extending and whether he will have an operation or not. None of the oculists I have seen have known of the method, and there may, consequently, be some advantage in making it public. I enclose for your inspection drawings, which I have made at intervals during the last three years, of a cataract which is slowly developing in one of my eyes. If you accept this communication please not to publish my name, as it might be a disadvantage to me in my business if it was thought that my sight was defective.

Yours truly,

J. S.

THE PHYSIOLOGICAL EFFECTS OF CITY AND SEASIDE AIR.

To the Editor of KNOWLEDGE.

SIR,—In your very valuable article in the March number of KNOWLEDGE on "Sewer Gas and Zymotic Disease," you refer to the mysterious difference in the physiological effects of city and seaside or mountain air. I venture to think that this difference is for the main part non-existent, and that the effects which are attributed to it spring mainly from other causes. Leaving out of sight the changes in the mode of life, and comparative freedom from care and worry, to which a great deal of the good influence which those experience who leave the city to take a holiday in the country is doubtless due, a great deal is also to be attributed to changes in the physical surroundings other than the quality of the atmosphere. In hot weather, the most important of these, I believe, is the greater practical coolness of the country, especially of mountains. In a large town, the effect of the heat of the air is greatly added to by the radiation of heat from bare roads, pavements and walls, and not diminished to the same extent as in the country by the movement of the air, which is impeded by the rows of houses.

It is during periods of excessive heat that the healthiness of towns falls most below that of the open country, except in very large towns where there are dense smoke-laden fogs. In cold weather, even when there are no such fogs, the air of large towns is commonly so much more smoke-laden and cloudy than that of the country as to shut out a great deal of the light and warmth of the sun, and thus gives rise to a lowering of vitality and spirits.

Close observation for many years has convinced me that these circumstances, and not any supposed difference in the quality of the air, are the source of the benefit derived from "a change into the country."

I am, Sir, yours truly,

Tunbridge Wells. EDW. G. GILBERT, M.D.

[Dr. Gilbert would have added to the interest of his letter if he had shown how he manages to distinguish between the beneficial effects produced by the various concurrent circumstances alluded to as generally accompanying the dose of fresh air.—A. C. RANYARD.]

THE FACE OF THE SKY FOR MAY.

By HERBERT SADLER, F.R.A.S.

SEVERAL large groups of sunspots have of late appeared on the solar surface.

Mercury is invisible during May. He is in superior conjunction with the Sun on the 20th.

Venus is a morning star, rising on the 1st at 3h. 15m. A.M., with a southern declination of 2° 19′, and an apparent diameter of $22\frac{3}{4}''$, $\frac{52}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on January 25th. On the 16th she rises at 2h. 47m. A.M., with a northern declination of 2° 34′, and an apparent diameter of $19\frac{3}{4}''$, $\frac{89}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on February 1st. On the 31st she rises at 2h. 21m. A.M., with a northern declination of 8° 37′, and an apparent diameter of $17\frac{1}{4}''$, $\frac{65}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on February 3rd. During the month Venus pursues a direct path through Pisces to the borders of Aries.

Mars is, for the purposes of the amateur observer, invisible; and Jupiter and Neptune have left us for the season.

Saturn is an evening star, and is well situated for observation. On the 1st he rises at 5h. 4m. P.M., with a southern declination of 5° 24′, and an apparent equatorial diameter of 18·6″ (the major axis of the ring system being 42·8″ in diameter, and the minor 9″). On the 16th he rises at 4h. 0m. P.M., with a southern declination of 5° 5′, and an apparent equatorial diameter of 18·4″ (the major axis of the ring system being 42·3″ in diameter, and the minor 8·6″). On the 31st he rises at 2h. 58m. P.M., with a southern declination of 4° 53′, and an apparent equatorial diameter of 18·0″ (the major axis of the ring system being 41·1″ in diameter, and the minor 8·2″). Titan is at his greatest eastern elongation on May 14th and 31st, and Iapetus at his greatest western on the 17th. During the month Saturn describes a short retrograde path in Virgo, but does not approach any naked-eye star.

Uranus is an evening star, and but for his southern declination would be well placed for observation. He is in opposition to the Sun on the 3rd, at a distance from the earth of about $1637\frac{1}{4}$ millions of miles. He rises on the 1st at 7h. 23m. P.M., with a southern declination of 15° 29′, and an apparent diameter of 3·8″. On the 31st he rises at 5h. 13m. P.M., with a southern declination of 15° 8′. During the month he describes a short retrograde

path in Libra, to the north west of a^1a^2 Libræ. A map of the stars near the path of Uranus will be found in the *English Mechanic* for March 23rd.

There are no very well marked showers of shooting stars in May.

The Moon is new at 2h. 41m. P.M. on the 5th; enters her first quarter at 6h. 21m. A.M. on the 12th; is full at 4h. 43m. P.M. on the 19th; and enters her last quarter at 8h. 4m. P.M. on the 27th. She is in perigee at 4h. A.M. on the 8th (distance from the earth 226,280 miles), and in apogee at 1h. A.M. on the 24th (distance from the earth 251,930 miles). At 7h. 55m. P.M. on the 12th the 6th magnitude star 37 Leonis will disappear at an angle of 88° from the north point, and reappear at 8h. 51m. P.M. at an angle of 340°. At 10h. 36m. P.M. on the 14th the $6\frac{1}{2}$ magnitude star B.A.C. 4043 will disappear at an angle of 76°, and reappear at 11h. 21m. P.M. at an angle of 355°. At 11h. 50m. P.M. on the 15th the $6\frac{1}{2}$ magnitude star B.A.C. 4294 will disappear at an angle of 120°, and reappear at 0h. 58m. A.M. on the 16th at an angle of 305°. At 2h. 19m. A.M. on the 19th the 6th magnitude star B.A.C. 5023 will disappear at an angle of 46°, and reappear at 2h. 53m. P.M. at an angle of 350°. At 10h. 58m. P.M. on the 19th the 6th magnitude star B.A.C. 5314 will disappear at an angle of 134°, and reappear at 0h. 14m. A.M. on the 20th at an angle of 271°. At 2h. 20m. A.M. on the 20th the 5th magnitude star B.A.C. 5347 will disappear at an angle of 164°, and reappear at 2h. 59m. A.M. at an angle of 223°. At 1h. 56m. A.M. on the 31st the $4\frac{1}{2}$ magnitude star ξ Piscium will disappear at an angle of 96°, and reappear at 2h. 40m. A.M. at an angle of 207°.

Chess Column.

By C. D. Locock, B.A.Oxon.

Communications for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 14.

Key-move—1. P to B5.

If 1. . . . P to R4, 2. B to Kt4.
1. . . . K×P, or K to Q6, 2. B to R5.
1. . . . P to Q6, 2. Q to R4ch.

Solutions of Problem No. 15.

Six Keys, viz.—Q to B2 (Author's), Q×B, Q to Ksq, either R×B, B×Kt
(For if 1. . . . P to Kt5, 2. Q to QBsq!).

Some apology is due for the insertion of so unsound a position. The problem was sent in by a well-known composer almost at the last moment, and was therefore accepted without due examination. One solver quaintly remarks that just as there is no end to a "circle," so for some time there seemed to be no end to its keys. Probably it would be difficult to "square" this "circle," which might be described as the "double nine-point circle," being worth eighteen points to some of our more persevering solvers.

Solution of Problem No. 16.

Key-move—1. R to Kt4.

If 1. . . . P×R or P to B5, 2. P to K5.
1. . . . Kt moves, &c., 2. P×Pch.
Dual after 1. . . K to K4 by 2. B to B6ch or Q to B6.
Also after 1. . . K to K6 by 2. P×P or 2. B×Pch.

Correct Solutions received from the following:—

Twenty-five Points.—Semper, Guy.
Twenty-three Points.—B. G. Laws.
Twenty Points.—A. C. Challenger.
Fourteen Points.—A Norseman.
Thirteen Points.—J. H. Christie.
Eleven Points.—Chat.
Ten Points.—A. R., Kt. J.
Nine Points.—Alpha, H. Holmes, E. W. Brook.

L. Bourne.—"No solution" to No. 15?! The others are correct.

H. G. Brandreth.—Solution to No. 14 correct. G, not S.

H. Holmes.—Thanks. The reply to you in last number was evidently an oversight.

A. E. Whitehouse.—None of your solutions are quite correct, though in No. 14, 1. B to Kt4 nearly solves the problem. We have no space this month for a detailed reply.

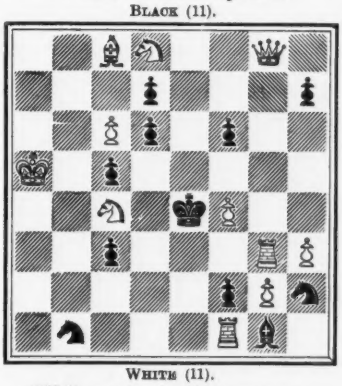
W. T. Hurley.—Your compulsory retirement is much to be regretted.

A Norseman.—Your solutions this month are even more unintelligible than usual. You are credited with three solutions to No. 15, but a fourth commencing 1. "QKtBB6" (whatever that may mean) is quite incomprehensible, the deduction of one point being the only course.

Position No. 17.

"*Posuit ultimum lapidem.*"

Black (11).



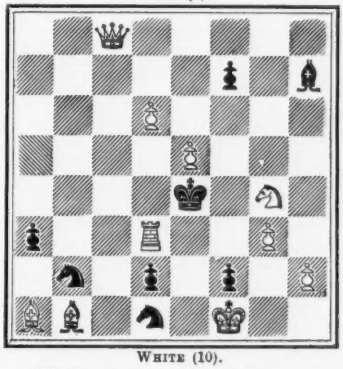
White (11).

White mates in three moves.

Position No. 18.

"*Fortes Fortuna juvat.*"

Black (8).



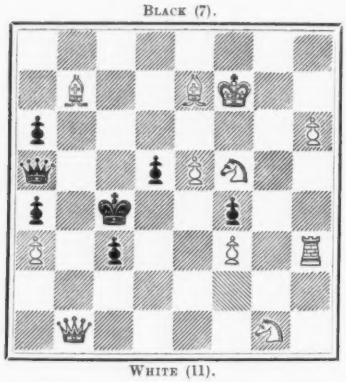
White (10).

White mates in three moves.

Position No. 19.

"*East Harling.*"

Black (7).



White (11).

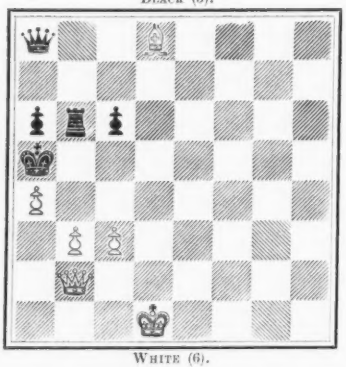
White mates in three moves.

[The above problems conclude the current tournament.]

CONDITIONAL PROBLEM.

By W. De Morgan.

Black (5).



White (6).

White mates in three moves, on condition that no piece may make two consecutive moves. [In order to prevent such solutions as 1. P to Kt4ch, K×P; 2. Q to Kt3 mate (!), it seems necessary to make an exception in favour of the Black King.] Solutions will be acknowledged.

Readers of Knowledge will be interested to know that the composer of the above is the son of the distinguished Prof. De Morgan.

CHESS INTELLIGENCE.

The first portion of the Steinitz-Lasker match is now over. Eight games were played at New York, resulting in four wins for Lasker, two for Steinitz, and two games drawn. The play, so far, has been of a brilliant character on both sides. Mr. Lasker has played the Ruy Lopez consistently, an opening in which Mr. Steinitz has succeeded in discovering just the cramped awkward defence that he revels in. Mr. Steinitz has of late years always done badly in the earlier stages of his matches. Under stress of urgent necessity he may possibly abandon the defence referred to; in any case, he is sure to play his best as the match enters on its final stage. The next instalment of the match is just commencing at Philadelphia.

The North *v.* South match was played in London on April 7th, with one hundred and seven players on each side. The result, after five hours' play, was a rather decisive victory for the South by sixty-four and a half games to forty-three and a half. No doubt the Northern team were severely handicapped by the long distances which many of them had to travel, and also by the absence of Mr. Skipworth and many of the leading Lancashire players. On the Southern side notable absentees were Messrs. Chepmell, Guest, Hunter, Mortimer, and Wayte, not to mention Mr. Donisthorpe, who deserted to the Northerners.

After the match the two teams were entertained at supper by the Reception Committee. The arrangements throughout were excellent. Mr. Blackburne again acted as umpire.

An analysis of the Southern score shows that the County players came out with a better average than the Metropolitan; Surrey, Sussex, and Somerset contributing in a large measure to the victory of the side. At the same time, it should be mentioned that most of the Surrey players are practically Londoners and members of London clubs. Last year no game was lost on the first twenty Southern boards; this year only one game on the same boards was lost. The Northern successes were almost entirely on the middle boards (Nos. 33 to 87). Here they obtained a slight majority, but not sufficient to balance the failure of the two ends of the team.

Late News.—Mr. Lasker won the ninth game.

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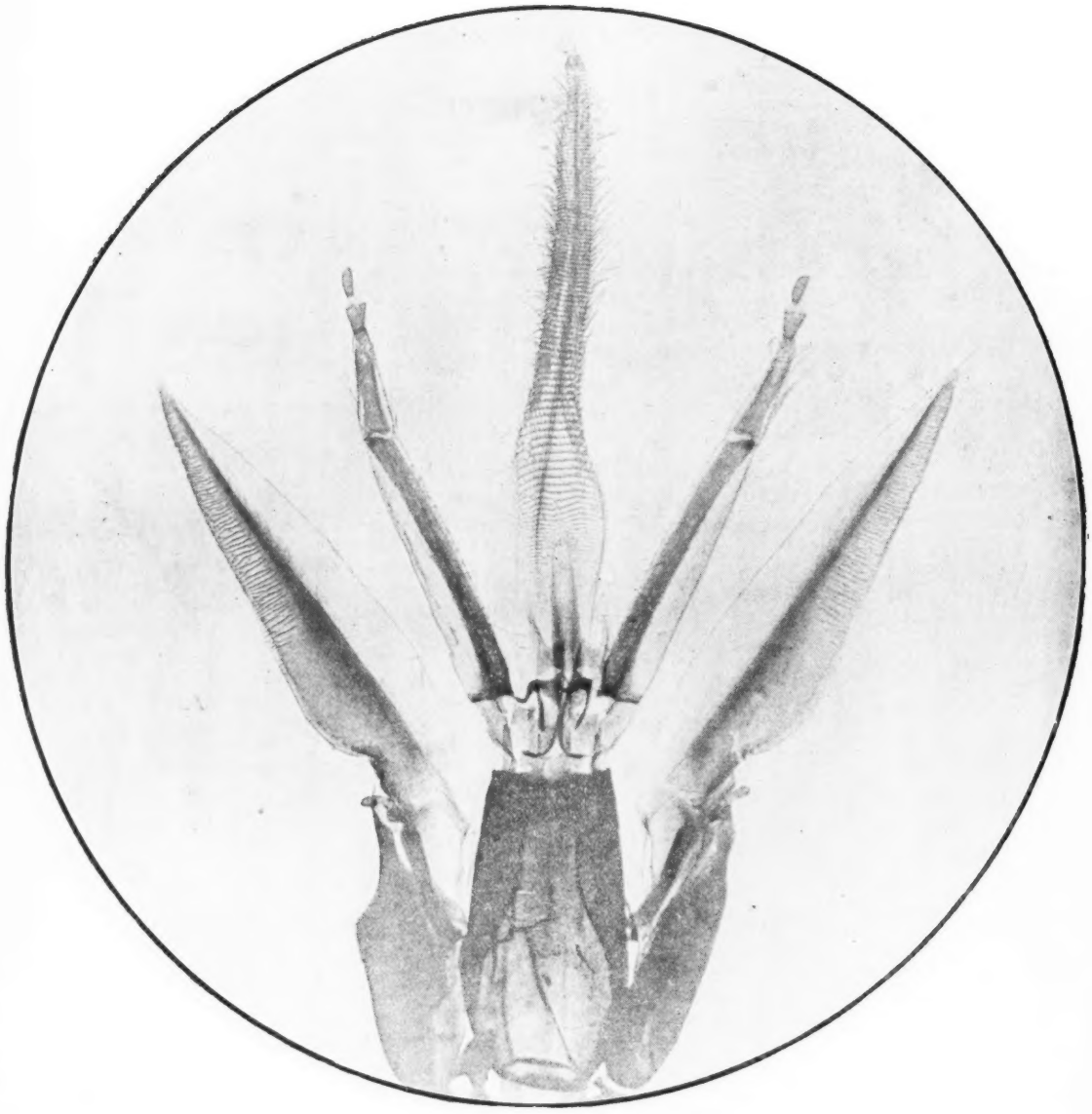

MOUTH ORGANS OF HIVE BEE.

At the sides are the blade-like maxillæ, or secondary jaws. Their palpi are exceedingly short, jointed organs, placed at the junction of the blade with the basal part. Between the bases of the maxillæ is the labium, which is prolonged as a long pointed organ, the ligula or tongue, which is very flexible, ridged, and beset with hairs. Branching from the labium at each side of the ligula are the long, jointed labial palpi. These and the maxillæ close round the ligula and enable the honey to be passed up into the mouth. Between the labial palpi and the ligula, at the base of the latter, are faintly traceable two small organs, the paraglossæ, which in some bees become proportionately much larger. The mandibles, or biting jaws, are not shown in this specimen.